ADVANCED VEHICLE-HIGHWAY TECHNOLOGY AND HUMAN FACTORS RESEARCH

HEARING

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

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ADVANCED VEHICLE-HIGHWAY TECHNOLOGY AND HUMAN FACTORS RESEARCH

WEDNESDAY, JUNE 7, 1989

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:35 a.m., in Room 2325, Rayburn House Office Building, Hon. Tim Valentine, [chairman of the subcommittee] presiding.

Mr. VALENTINE. Ladies and gentlemen, the Subcommittee on Transportation, Aviation and Materials will come to order.

Before we begin, the subcommittee has a piece of unfinished business to attend to. It is a matter left over from last week's mark-up of H.R. 2365, the airport security legislation, and H.R. 2241, aero-space plane legislation.

Because a sufficient number of members were unable to attend the meeting, we were unable to complete action on these two bills. Therefore, without objection, I would propose at this point to entertain a motion to report the two bills to the full committee and, further, without objection, I will ask the Clerk to call the roll at this time to record the votes of those members present and then, as other members arrive, their votes will be recorded.

Let me say before I recognize other members that the record will show that due and appropriate notice under the rules was given for the previous meeting, timely notice, I am advised by staff, and all members of the subcommittee were reminded by telephonic communication and by note in writing that we would take this matter up again today.

If there are any members who have any questions about this procedure, then we will hear from them at this time.

If not, I will recognize Mr. Lewis for a motion.

Mr. LEWIS. Thank you, Mr. Chairman. I move that the subcommittee report to the full committee the subcommittee actions on H.R. 2365 and H.R. 2241, and direct the staff to prepare such material as may be necessary to reflect the action taken.

Mr. VALENTINE. Those members favoring the motion will vote aye and those opposed, no.

The Clerk will call the roll of the subcommittee.

The CLERK. Mr. Valentine.

Mr. VALENTINE. Aye.

The CLERK. Mr. Lewis.

Mr. LEWIS. Aye.
The CLERK. Mr. Glickman.
[No response.]
The CLERK. Mr. Shays.
[No response.]
The CLERK. Mr. McCurdy.
[No response.]
The CLERK. Mr. Rohrabacher.
[No response.]
The CLERK. Mr. Nelson.
[No response.]
The CLERK. Mr. McMillen.
Mr. MCMILLEN. Aye.
The CLERK. Mr. Campbell.
Mr. CAMPBELL. Aye.
The CLERK. Mr. Brown.
Mr. BROWN. Aye.

Mr. VALENTINE. We will leave the record open and, as other members come in, they will have—during the course of these proceedings, they'll have an opportunity to—to vote.

Today, the subcommittee will take a long-range look at the future of automobile transportation in the United States. First, I want to welcome each of you here today and to thank you for your participation in this timely subject.

Before we get to the subject at hand, I would like to invite members of the subcommittee and the public who are here to see the Pathfinder vehicle that will be displayed at the bottom of the Rayburn Horseshoe around 12:30 this afternoon. This vehicle is part of ongoing research in the California area and is equipped with a so-called in-car navigation and computer system needed to make a thorough evaluation of how to handle traffic congestion in the Santa Monica "smart corridor" in Los Angeles.

The subcommittee wishes to thank those responsible for the presence of this vehicle and this equipment here today and I say again, I urge those within the sound of my voice to avail themselves of the opportunity to—to see this phenomenon.

Most commuters would agree that traffic in most metropolitan areas in this country is a mess. This morning, in this area, was a pretty good example. If present trends continue unchecked, this situation will get even worse.

Throughout the '80s, the total volume of urban traffic has grown by about 5 percent per year. The forecast for the future indicates that there will be a five-fold increase in congestion and that a 10- to 15-minute commute in 1989 will stretch to about one hour—to about one hour early in the next century.

Further, it is estimated that traffic delays and congestion cost the economy roughly $73 billion annually. Given the need to maintain a strong and productive economy, we can no longer afford to continue under these conditions. The purpose of today's hearing is to assess the development of smart cars and highways and to help alleviate traffic congestion.

Smart cars will rely on computers and radio signals beamed up from—these beamed up from smart highways to keep them spaced safely and to keep them moving smoothly. The signal could both

steer the car and tell the computer where the vehicle is. The computer programmed with the desired route would automatically guide the car to the proper exit. Radar exits would detect nearby vehicles or obstacles and maintain safe distances.

The purpose of today's hearing is to learn more about these and other related technologies and to examine the proper Federal role in implementing them. We look forward to the comments of our expert witnesses and to the discussion of the surrounding issues.

And I will recognize at this time the ranking member of the subcommittee, our good friend, Mr. Tom Lewis.

Mr. LEWIS. Thank you, Mr. Chairman.

If the nation is to avoid daily gridlock, as experienced today, on major highways from coast to coast, we must develop new vehicle and highway technologies to address these problems. However, the research program must be developed around a national transportation policy in order to be effective.

Not all research attempts are completely successful. For example, the Department of Defense attempted to develop a truck that could both plot and steer its own course. At first, the vehicle had difficulty staying on-road because shadows confused it, thereby limiting it to use at noon. Finally, the glitch was corrected so that it could travel at 12 miles per hour on straight roads. Unfortunately, off-the-road success has been limited to 600 yards at two miles per hour.

This information is about all that the popular press reports. In this case, the major research successes involve the computer programs to operate the truck, which has wide application to civil transportation. The point is that more research is needed in this area.

In the civil sector, we need an aggressive research program to address these and other problems that face vehicle and highway technology over the next 25 years.

This hearing is a step in the direction of assessing the nation's long-term transportation needs of the future. I compliment the chairman for his leadership in this area and look forward to today's hearing.

Thank you, Mr. Chairman.

Mr. VALENTINE. We will recognize Mr. McMillen at this time for—do you have an opening statement?

Mr. MCMILLEN. I have no statement, Mr. Chairman.

Mr. VALENTINE. Mr. Campbell.

Mr. CAMPBELL. Thank you, Mr. Chairman. I'll be very brief. I also compliment you for holding these hearings and look forward to hearing the witnesses' expert testimony.

In view of conflicting schedule of events, I may not be able to attend all of it, but I did want to pay particular attention and ask the committee's particular attention to the testimony of Mr. Randy Doi, from Motorola. I have long been familiar with Motorola, even back to the days when I used to help represent them in the practice of law.

In particular, though, I draw attention to the fact that Motorola has achieved the most unique record in technological achievement by being the very first recipient of the Malcolm Baldrige Quality Award, and I particularly point to Mr. Randy Doi, the Director of

the Intelligent Vehicles/Highway Systems Division of Motorola as one of the nation's foremost experts in automotive electronics.

I look forward to all the testimony of all the witnesses and particularly that of Mr. Doi.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, sir.

Mr. Brown.

Mr. BROWN. Thank you, Mr. Chairman.

I do have a couple of words that I'd like to get in the record, particularly involving California, but I want to join in complimenting you on holding these hearings.

I would tell you, just from a very practical political standpoint, there is no issue of higher priority in southern California, the area which I represent particularly, than the congestion of the highways. That is the number one quality-of-life issue exceeding almost every other. And the estimates are that it's going to get worse.

We expect to have nine million more people with eight million more cars in the next 20 years in California and the average commuting time will probably hit two hours, as compared with 45 minutes today, and the average travel speed will probably drop by 50 percent, from roughly 35 miles per hour to 19 miles per hour. Of course, more than half that daily travel time will be spent at a dead stop on that huge parking lot that we know as freeways down there.

We hope that that can be avoided. It represents a tremendous loss of productivity, a tremendous insult to the environment, tremendous overconsumption of energy and only through the research programs that are under way can we hope to solve some of these, amongst which is the Pathfinder project, which you have already referred to.

I'm particularly pleased that you have invited Mr.—Dr. Bob Parsons, who—to participate this morning. I've known him for a number of years. He was in charge of the superspeed train study, involving Los Angeles and Las Vegas during the time when I was chairman of this subcommittee and he's now heading up the PATH program at the UC Berkeley.

We're looking forward to hearing his comments here this morning and I commend them to the other members of the committee and look forward to the results of this hearing.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, Mr. Brown. Always good to hear your words of wisdom. The situation which will exist, as you have pointed out, particularly in California, in the years ahead is—is a real horror story. I mean, it is quite frightening and if the information which is—the estimates, which are available to us, are even true as a rough estimate, then we are in for real troubles in that part of the country, which is the reason that you have—one of the reasons that you have been invited here to give us the solution.

We look to you and we know that you have all the answers, and of course, the Congress can be expected to act promptly to remedy the situation.

The first panel which I'm pleased to welcome here today consists of Mr. Michael Finkelstein, Associate Administrator of Office of Research and Development, National Highway Safety—Highway

Traffic Safety Administration; and Mr. Lyle Saxton, Assistant to the Executive Director for Advanced Technology, Federal Highway Administration.

Your prepared statements, which have been presented to the subcommittee, will appear in the record and you may summarize or otherwise proceed as you deem appropriate. Welcome.

STATEMENTS OF MICHAEL FINKELSTEIN, ASSOCIATE ADMINISTRATOR, OFFICE OF RESEARCH & DEVELOPMENT, NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION, DEPARTMENT OF TRANSPORTATION; AND LYLE SAXTON, ASSISTANT TO THE EXECUTIVE DIRECTOR FOR ADVANCED TECHNOLOGY, FEDERAL HIGHWAY ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

Mr. FINKELSTEIN. Thank you very much, Mr. Chairman.

I'm Michael Finkelstein, of the National Highway Traffic Safety Administration, and I'm pleased to appear before the subcommittee today to discuss my agency's views on advanced highway vehicle technology and human factors research.

Motor vehicle crashes are the leading cause of death and injury for young people in the United States.

Mr. VALENTINE. Would you excuse me just—

Mr. FINKELSTEIN. Yes, sir.

Mr. VALENTINE. —one minute, please, sir, and let me finish the little piece of unfinished business here.

The Chair would announce at this time that a quorum is present and that the motion has carried, the motion on the question that I previously put with respect to legislation, has carried.

All right, sir.

Mr. FINKELSTEIN. Thank you, sir.

My agency's interest in advanced highway vehicle technology deals with the problem of safety. For a person under 34 years of age, the motor vehicle crash is the leading cause of death in this country. In 1988, we estimate that in excess of 47,000 people died on our highways, 3.5 million people were injured on our highways and the economic losses resulting just from crashes exceeded $75 billion.

As the number of vehicles increase and travel increases, we will expect these numbers to rise as well, unless we can come up with effective interventions.

We've been successful; we have a number of successes, but the growth in in travel is such that we cannot stop now and rest on our success.

The occupant crash protection advances that are going to be in all vehicles in 1990 as a result of Federal motor vehicle safety standards will save enormous numbers of lives. Air bags and automatic safety belts will reduce fatalities by substantial numbers, and that's the product of research. It was the product of scientific investigations which showed how people who were injured in crashes could be saved; how we could more efficiently manage energy in crashes, and, as a result, reduce the likelihood of a vehicle occupant being injured or being killed.

What we're now looking for is technology that's available to avoid crashes. We believe that if we approach the issue of crash avoidance scientifically, we can make the same kind of improvements. The difficulty, however, is that crashes do not have single causes. Most crashes have a number of causes and the principal contributing factor is the human factor, is the driver. The driver is the primary cause or the contributor to in excess of 80 percent of all crashes. Lapses in judgment, lapses in maneuver execution, inability to detect risks, all contribute to the crashes that occur.

While we can describe what goes on, unfortunately, our level of understanding to—as to what the sources of these lapses are is not nearly high enough to intervene. The continuing development of innovative technology has the potential to provide solutions to some of these problems. It may be that new developments in electronic technology give us better means of analyzing the driving task and leading to improvements in a vehicle that can expand the driver's margin of safety in high-risk environments.

A number of electronic innovations, such as anti-lock brakes, are already on the road in large numbers and we anticipate that the driver's margin of safety will increase by development of smart vehicles and highways that give drivers a better sense of impending danger and that can even compensate for this lack of judgment or lack of skill.

Overseas, in Europe, an existing advanced technology program is already under way. It's called PROMETHEUS, and it has a number of goals, but one of the principal goals is to strengthen the European Economic Community's role in the global automotive electronic market. They seek to promote the intelligent use of road space and, in the area that my agency is most interested, they've established the goal of reducing crashes by 50 percent in the next 20 years. Safety is a very key element in the European effort dealing with intelligent highways.

They intend to design intelligent vehicles to operate on intelligent highways with electronic traffic flow detectors, improving communications between drivers and providing automatic crash avoidance. The general objectives are to improve safety, efficiency and convenience and to reduce the environmental impact of automobile travel.

This is an eight-year, $800 million research program that has resulted—that is, including the participation of all of the leading European-owned auto manufacturers, over 100 automotive suppliers, 70 research institutes and five European governments.

Since one of the program's goals is to achieve European dominance in the electronics market, non-European auto manufacturers have been strictly prohibited from participating in the program. They expect to complete their work by 1994.

Within the United States, efforts are under way, but they're proceeding much more slowly. A major goal of the embryonic U.S. intelligent vehicle highway system is also to help reduce road congestion, which has been alluded to by the chairman, by Mr. Brown and by other members of the subcommittee.

Another goal of our effort, of course, is to improve the safety of the highway system.

The National Highway Traffic Safety Administration's principal focus and responsibility in this activity so far has been on the vehicle and the driver/vehicle interaction. Our agency has begun to address these programs. We are actively participating in the deliberations of Mobility 2000, which is an ad hoc committee formed to provide focus for the U.S. effort. NHTSA, together with the Federal Highway Administration, is also contributing to DOT's report to Congress on the intelligent vehicle highway system program that was requested by our appropriations committees in the fiscal year 1989 DOT Appropriations Act.

At the State level, we've provided seed money for initial planning studies on IVHS-related issues with the University of California at Berkeley, the University of Michigan, Texas A&M and MIT.

In addition, we're involved in a cooperative program with Caltrans, with Ford Motor Company and Radar Control Systems, a San Diego-based firm, to evaluate the application of collision-avoidance technology as a means of enabling vehicles traveling in a group to maintain safe intervals. This is work on obstacle detection capability and its implementation in traffic systems.

Within the agency, we've initiated a series of crash data analyses to better understand the distributions of crashes, fatalities and injury levels versus location, time of day, driver error and the like in order to better target our programs.

Although we can assume some reduction in the risk of crashes would accompany any reduction in traffic congestion, care must be taken in the implementation of new vehicle highway systems to avoid degradation of safety, particularly through the creation of human factors problems. For example, it's possible that a proliferation of information channels and displays could distract, rather than help, drivers.

One research task, therefore, that is of paramount importance is to evaluate the ability of drivers to assimilate more information so that no loss of safety occurs as new driver aids or control resources or crash-avoidance technology makes its way into cars. A major prerequisite for the development of this is research to improve our understanding of driver/vehicle interaction.

Part of the reason for our limited understanding of the contribution of human factors to crashes is the great difficulty to conduct relevant human factors research safely under controlled repeatable conditions. As a result, our efforts to understand pre-crash events and develop safety countermeasures are hampered by a lack of knowledge and understanding of the factors determining the effects of driver predisposition, response and performance.

Let me illustrate with a few examples. We know that visual performance, information evaluation and timely decisionmaking are critical to driving, but we do not know what specific visual capabilities are required, what measures of visual or cognitive workload are meaningful or what measures and criteria of acceptable driver performance should be used.

We know visibility from a vehicle is a requisite for safe driving, but we don't know how to quantify this. We know that a driver uses a variety of tasks to control a vehicle while driving, but have little understanding of what the cues are, how to quantify them and how a driver adjusts to changes.

Critical to the success of human factors research will be projects to develop and validate research and analysis tools to obtain data, evaluation protocols for assessing potential safety degradation or benefits of intelligent vehicle systems and decision aids to support the choice of research directions.

We're currently working through the National Science Foundation with the University of Iowa to examine the technical and economic feasibility of developing a state-of-the-art driving simulator to address some of these issues. At this point, the Department has not yet determined whether there need be a national program for the development and implementation of intelligent vehicle highway programs. Recently, the Department distributed a discussion paper on these issues to solicit comments from the transportation community, the research community and the public at large on this subject and on the merits of a national—of a commitment to a coordinated national research program and the approach that should be taken to fund such a program.

The comments on this paper will be used in preparation for the report to Congress that I had mentioned earlier.

If a national research development and demonstration effort is warranted, a strong organizational framework will be needed to bring together the public and the private interests in this area. The organizational options to provide this cooperative framework are also being reviewed.

When the administration's review is completed and the Department's report is submitted, we will be better prepared to discuss recommendations for legislative or programmatic changes.

This concludes my remarks and I'd be happy to answer any questions, particularly on technology issues and safety. Thank you.

[The prepared statement of Mr. Finkelstein follows:]

STATEMENT OF MICHAEL FINKELSTEIN
ASSOCIATE ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
BEFORE THE SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
REGARDING ADVANCED VEHICLE-HIGHWAY TECHNOLOGY
AND HUMAN FACTORS RESEARCH

June 7, 1989

Mr. Chairman and Members of the Committee.

I am pleased to appear before you today to discuss the National Highway Traffic Safety Administration's (NHTSA) views on advanced vehicle-highway technology and human factors research.

Motor vehicle crashes are a leading cause of death and injury in the United States. For a person under the age of 34, in fact, a motor vehicle crash is the leading cause of death. In 1988, motor vehicle crashes resulted in 47,093 deaths, an estimated 3 1/2 million injuries, and total economic costs in excess of $75 billion. As the number of vehicles on the road and the number of miles travelled increase, the number of deaths and injuries will also increase unless effective safety measures can intervene. While we have made great strides in highway safety -- the fatality rate in 1988 of 2.4 fatalities per 100 million vehicle miles travelled is the lowest ever recorded -- more must be done to reduce the magnitude of the highway safety problem.

We believe that the new occupant crash protection devices that will be required in all passenger cars for the 1990 model year will help to reduce the crash toll. These devices, including air bags and a variety of automatic safety belts, are helpful in preventing injury once a crash

has occurred. They are the product of research which showed how people were injured in frontal crashes and how specific safety improvements could help prevent injury.

We would like to be able to apply similar techniques to the prevention of crashes, but we face the difficulty that most crashes do not have a single cause. Studies show that human factors are involved in virtually all crashes, as either the sole cause or a contributory cause, but while these factors can be described -- as lapses in detection, perception, judgment, risk assessment, manuever execution, and so on -- we frequently do not fully understand the sources of these lapses or what type of countermeasures would prevent them.

The continuing development of innovative technology by the scientific and engineering communities has the potential to provide solutions to some of the human factors problems. It may be that the new developments in electronic technology will give us a better means of analyzing the driving task and lead to improvements in the vehicle that will expand the driver's margin of safety in high-risk environments. A number of electronic innovations, such as antilock brakes, are already on the road in large numbers. We anticipate that a driver's margin of safety could be further increased by developing "smart" vehicles and highways that give the driver a better sense of impending dangers and that compensate for lapses in judgment or skill.

The European effort

The major, existing advanced technology program in this area--Europe's PROMETHEUS program--is designed to strengthen the European Economic Community's (EEC) role in the global automotive electronics

market, to promote the intelligent use of road space and vehicle safety while reducing emissions and energy consumption, and to integrate traffic systems with vehicle management. Safety is a key element of this program.

The goal of the PROMETHEUS research effort is to design "intelligent vehicles" and electronic traffic flow detectors that improve communications between drivers and provide automatic crash avoidance. The general objectives of this effort are to improve traffic safety, efficiency, and convenience, and to reduce the environmental effects of automobile travel, such as air pollution. The guiding principle behind this eight-year, $800 million program is the gradual development of the automobile from an individual guided vehicle to one which operates as an integral part of a more efficient and safe traffic network.

PROMETHEUS involves all the leading European-owned car companies, over 100 automotive suppliers, and 70 research institutes. Since one of the program's goals is to achieve European dominance in the electronics industry within the next decade, non-European firms have been strictly prohibited from participating in the program. The research topics for the program have been published and the research is scheduled to be completed in 1994.

Status of U.S. efforts

A major goal of the embryonic U.S. intelligent vehicle-highway system (IVHS) program (also referred to as the advanced vehicle-highway system, or AVHS) is to help reduce the road congestion that is already a serious problem in many parts of the country and is predicted to spread to other areas in coming years. Another goal is to improve the safety of the

highway system. The testimony presented by the Federal Highway Administration has focused on these efforts. The National Highway Traffic Safety Administration's principal focus and responsibility has been on the vehicle and the driver/vehicle interaction.

The agency has begun to address IVHS issues. We are actively participating in the deliberations of Mobility 2000--the ad hoc committee formed to provide a focus for U.S. IVHS efforts. NHTSA, together with the FHWA, is contributing to DOT's report to Congress on IVHS programs that was requested in the Conference Report on the FY 1989 DOT Appropriations Act. On the State level, we have provided seed money for initial planning studies on IVHS-related issues with the University of California at Berkeley, the University of Michigan, Texas A&M University, and the Massachusetts Institute of Technology.

In addition, the agency is involved in a cooperative program with the California Department of Transportation, Ford Motor Company, and Radar Control Systems to evaluate the application of collision avoidance technology as a means of enabling vehicles travelling in a group to maintain a safe interval. Within the agency, we have initiated a series of crash-data analyses to better understand the distributions of crashes, fatalities, and injury levels versus location, time of day, etc., in order to maximize potential safety improvements through advanced technology developments that have the highest probability of pay-off.

Although it may be assumed that some reduction of the risk of crashes would accompany a reduction in traffic congestion, care must be taken in the implementation of new vehicle-highway systems to avoid degradation of safety, particularly through the creation of human-factor problems. For example, it is possible that a proliferation of information channels and displays could distract a driver, rather than help. One research task,

therefore, is to evaluate the ability of drivers to assimilate more information so that no loss of safety will occur as new driver aids, control resources, and crash avoidance systems are implemented.

A major prerequisite for the development of intelligent vehicle-highway systems is research to improve the understanding of driver-vehicle interaction issues. Part of the reason for our limited understanding of the contribution of human factors to crashes is the great difficulty in conducting human factors research safely under controlled and repeatable conditions. As a result, our efforts to understand pre-crash events and develop safety countermeasures are hampered by the lack of knowledge and understanding of the factors determining the effects of driver predisposition, response and performance in potential crash situations.

Let me illustrate this problem with some examples:

* We know that visual performance, information evaluation and timely decision-making are critical to driving, but we do not know what specific, visual capabilities are required, what measures of visual or cognitive workload are meaningful, or what measures and criteria of acceptable driver performance should be used in the conduct of research.

* We know visibility from a vehicle is requisite for safe driving, however, we really do not know how to quantify this value and thus find it difficult to estimate a minimal requirement.

* We know that the driver uses many visual, auditory, and tactile cues to control the vehicle while driving, but we have little understanding of what these cues are, how to quantify them, how the driver utilizes them, or how the driver adjusts to changes in these cues.

Critical to the success of human factors research will be projects to develop and validate research and analysis tools to obtain data, evaluation protocols for assessing potential safety degradation or benefits of intelligent vehicle systems, and decision-aids to support

choice of research directions and agency actions. We are currently working through the National Science Foundation with the University of Iowa to examine the technical and economic feasibility of developing a state-of-the-art driving simulator.

At this point, the Department has not determined whether there needs to be a national program for the development and implementation of IVHS programs. Recently, the Department distributed a discussion paper on IVHS programs to solicit comments from the transportation community and the public at large on this subject and on the merits of a commitment to a coordinated national IVHS research deployment program and the approach that should be taken to fund an IVHS program. The comments on this paper will be used in the preparation of the report to Congress that I mentioned earlier.

If a national research, development and demonstration effort for IVHS programs is warranted, a strong organizational framework would be needed to bring together the public and private interests in this area. The organizational options to provide this cooperative framework are also being reviewed. When the Administration's review is completed and the Department's report to Congress is submitted, we will be better prepared to discuss any recommendations for legislative or programmatic changes that seem advisable.

Mr. Chairman, this concludes my remarks. I will be glad to try to answer any questions you may have.

Presented at the Twelfth International Technical Conference on Experimental Safety Vehicles Gothenburg, Sweden May 31, 1989

Session 3B: FUTURE MOTOR VEHICLE SAFETY RESEARCH NEEDS: CRASH AVOIDANCE

Remarks by: Michael M. Finkelstein
Associate Administrator for Research and Development

In 1942, Hugh DeHaven published a paper in the Journal of War Medicine examining the liklihood of individuals surviving falls from heights of greater than 50 feet. The paper discovered that when loads were distributed and when energy was absorbed by the impacted object (by bushes, snowbanks, etc.), the probability of survival was increased. When loads were concentrated or when the individual hit an unyielding object, the subject did not usually survive.

DeHaven's keen mind made sense out of situations that others had never thought to examine very carefully. In retrospect his conclusions were obvious. But in fact, his contribution to a new field was enormous, because of his insight. The result was the beginning of the science of motor vehicle occupant protection.

Anther giant in the field of injury control was William Haddon. Dr. Haddon made many important contributions to the field, but none was greater than the well known Haddon mattrix. In 1968, in the American Journal of Public Health, Haddon organized the highway safety problem into a three-by-three mattrix that examined the driver, the vehicle and the highway during the pre-crash, crash, and post-crash period.

Again, when examined after the fact, this characterization of the highway safety problem is so obvious as to require almost no explanation. Like DeHaven, Haddon had examined a problem and provided a rational means of addressing it. The framework he provided has been used by virtually every researcher in the field.

A more recent contribution that is widely recognized for its importance, was included by A. C. Malliaris in his 1982 SAE paper on crashworthiness priorities. Dr. Malliaris used the concept of harm to form the basis for the characterization of the motor vehicle crashworthiness problem. Conceptually, what could be more compelling than using damage to the vehicle occupant as the basis for approaching occupant protection. Malliaris was able to disaggregate the crashworthiness problem into its components, organizing the data according to the part of the body that was injured, the part of the vehicle that caused the injury, and then ranking these factors by relative harm.

Like the contributions of DeHaven and Haddon, Malliaris' insight is in retrospect, very straight forward. It did not require assembling new data or conducting new research. Like his predecessors he made sense of the information at hand and helped move the field of crash protection forward.

When we turn to the subject of crash avoidance, we do not yet have a recognized framework around which we can organize a program. While much valuable crash avoidance research can be and has been pursued, as a profession, we have a difficult time relating the research to changes in the safety of our motor vehicle/highway system.

Unlike the field of occupant protection, where we have been able to disaggregate the problem into manageable projects and estimate the effect that those projects have in the overall scheme, we have not been able to do this with crash avoidance.

In large part, this stems from the fact that most crashes do not have a single cause but involve a number of contributing factors. Moreover, even if they did and we could accurately identify that cause, we could still reduce the likelihood of a given crash re-occurring without necessarily treating <u>that</u> particular cause, but by treating any one of a number of factors.

A concrete example might serve to illustrate this. While no fatal crash is typical, the one that follows is all too common. The description on the police accident report would include the following information:

Time of crash: 2:00 AM, Saturday
Location of crash: 2 lane rural highway
Vehicle: 8 year old passenger car
Driver: 20 year old male
Weather: rain

The report describes a fatal crash where a young driver was speeding, he entered a curve going too fast, he hit his brakes and lost control of the car. The vehicle left the road and struck a tree, and the driver (who was not wearing his safety belt) was killed on impact.

We would correctly attribute the primary cause of this crash to driver error, with speed being the principal component of that error. However, if this crash occurred on a typical rural road, there probably were no visible edge markings to help the driver -- particularly an inexperienced driver. Further, a newer car might have had antilock brakes, reducing the liklihood of loss of control during braking. Newer tires might also have helped improve vehicle traction. Better lighting, either road-based or vehicle-based, or better driver training, could

have also changed the outcome. (Of course, if he had worn his seat belt, he might not have been in our fatal accident file at all.)

Were we to examine future technologies such as vehicle sensing, interactive highway/vehicle communications, vision enhancement, obstacle detection, or a variety of driver warning systems, they also could be expected to reduce the frequency of these kinds of crashes.

The point of this discussion is that even though we have identified the principle cause of the crash as "driver error" there are a very large number of interventions, all of which could reduce the likehood of that crash happening.

We could look at multi-vehicle crashes, daytime crashes, crashes involving drug or alcohol use, crashes involving vehicle defects or almost any other subset of crashes. For each class of events, it is possible to identify a wide variety of potential interventions that, if applied, could reduce crash frequency.

The dilemma we face is how are we to select from among an enormous number of potential research avenues and determine where our collective energies should be focused. Is it possible to rationally make these decisions?

At this point it might be useful to take inventory of what information we have and then address the question of what is needed to develop a crash avoidance research agenda.

First, in the U.S., there are three sources of data on crashes.

- We have a census of fatal crashes -- the Fatal Accident Reporting System -- FARS. This system reports on between 40 and 50,000 crashes per year and has been in existence since 1975. FARS provides information available from police accident reports (crash conditions, time, location, vehicle type, driver information, etc.), driver records, vehicle registration files, and from medical examiners records (alcohol presence etc.).

- We have a nationally representative sample of police reported crashes -- the National Accident Sampling System -- NASS. This system reports on approximately 8,000 light vehicle crashes each year and has been in operation at this level since 1981. It differs from FARS in that each NASS case includes a careful examination of the vehicle (to determine crash severity, contacts with the occupant, etc. and a full determination of all injuries, usually based on hospital records.

- We have available the automated accident records for approximately 25 states. These files contain police accident reports on more than 3 million crashes each year. These data include vehicle identification, crash conditions (location, trajectory, etc.), and occupant information (driver age, level of injury, etc.). The records from six of these states have been used to assemble a Crash Avoidance Research Data File (CARD file). This particular file contains over 4 million crashes and permits NHTSA, for the first time, to inventory the crashes that occur and stratify them in a variety of ways -- using driver, vehicle, highway, or accident descriptors as relevent parameters.

Taken together, these data make it possible to fairly accurately describe the crash environment. We can take almost any possible combination of factors and use them to disaggregate the available information. We can describe injury outcome as a function of roadway alignment. We can examine police reported driver errors as a function of age, as a function of highway classification, as a function of injury severity, for any kind of crash (multi-vehicle, single vehicle, rollover, frontal, etc). We can identify the pre-crash driving maneuver for almost any classification of crashes.

When it comes to the available data, it appears that we have a multitude of riches. We now need to learn how to better use these data -- not press to collect more.

Within NHTSA, these data sets are used to focus our research. For example, we are examining information on rollovers and trying to determine what particular events preceded the rollover. This could allow us to begin concentrating on potential countermeasures such as brake system changes or suspension modifications.

From that point, we could then define engineering programs aimed at enhancing vehicle stability. We know how to evaluate the changes in performance that could result from such engineering programs. Unfortunately, the most difficult, and relevant, evaluation cannot be so readily completed -- that is; estimating the effect that these changes would ultimately have on safety.

What is missing is a practical body of human factors data. As long as vehicle operation remains the responsibility of the driver, it is critical that we understand how the driver responds and reacts in a variety of situations. Driving consists of perceptual and cognitive tasks. The range of driver perceptual and cognitive skills will have an important bearing on what occurs. It would appear that our greatest gap in knowledge is how to adequately characterize the driver.

The driver is continually receiving information, analyzing information, and acting upon these analyses. While we can describe the process, the precise equations defining these processes elude us. In crashworthiness we have developed dummies in order to measure crash forces on humans. It is much more difficult to even understand what kinds of surrogates can be used in crash avoidance research. Complicating an already complex situation is the fact that the performance of an individual is not fixed — but continually changes. And how the population of drivers responds to an enormous variety of driving situations is what defines the highway safety environment.

Using occupant protection as an example, we develop our research agenda in a rather straightforward way.

- First, we define the problem, usually by crash mode, by injury source (vehicle contact), by injury type (body part), severity), using harm as our measure.

- Second, we consider ways in which we can accomplish two objectives, -- either preventing the occupant from contacting the vehicle interior or managing the forces when contact occurs. We then estimate benefits.

- Third, we determine how to measure the reductions in force on the human that we seek to achieve, the performance test.

- Fourth, we develop measurement tools, evaluate potential countermeasures and verify our earlier estimate of benefits.

In the field of crash avoidance, this model breaks down fairly quickly.

While we have sufficient information to describe the crash avoidance problem, we still need to agree upon the proper means of using this data to do so.

But where the model really breaks down is at the second step. Unlike the occupant protection model with only two choices, -- either avoid contact or manage forces; in crash avoidance we have an almost unlimited array of choices and very little experience in estimating benefits. We do not yet have an agreed upon methodology that we can use to make decisions. But this does not mean that we have not had some successes.

The field studies that produced the information in support of the center high mounted stop lamps stand as an important achievement in crash avoidance research. The studies were pursued first, on the basis of our general understanding of the driving task; second, because the potential countermeasures had very little risk of adversely impacting safety; and third, the

countermeasures, and thus the studies, could be pursued relatively inexpensively. Unfortunately, more often than not, this combination of factors is not present.

Returning to the fatal crash described earlier, how can we evaluate the choices of countermeasures available. Which of them should we concentrate on? When faced with an inexperienced driver, late at night, losing control while speeding on a curve, which of the following interventions should we pursue:

brake system changes
driver education
tire traction improvements
roadside delineation
headlighting improvements
suspension modifications

or how can we evaluate the improvement that might be available through advanced technology such as

interactive highway/vehicle communications
vision enhancement
obstacle detection
vehicle sensing technology
active suspension
driver impairment detection systems.

In many cases the potential choices are too expensive to use in field studies or carry with them the risk of adverse consequences if we overload the driver or if we misapply the technology.

To get around these problems, we need to develop an accepted body of driver performance data. Whether this is done with instrumented vehicles, with research simulators, or other techniques, the absence of the information is a major obstacle to progress.

In the more than 40 years since DeHaven produced his landmark study, great progress has been made in occupant protection. And the progress is in large part the product of the scientific community.

During that same period, there has also been a very large reduction in crash frequency. But the credit for this must be shared with our road builders, with our citizen activists focusing on issues like drunk driving and safety belt use laws, and of course with our vehicle designers who were improving the vehicle, but largely to make it more comfortable, not necessarily safer.

We have the opportunity to make major improvements. The application of advanced technology to the motor vehicle carries with it tremendous potential for improving safety. The 50 percent reduction in crashes that the PROMETHEUS Project has as its goal recognizes that potential. Our challenge is to develop the research programs that will achieve that goal.

Investments in human factors research are hard to sell to our management, whether we work for a government, a motor vehicle manufacturer or a research institute. These investments are not closely linked to specific products or specific regulations -- and in a world where highway injuries and fatalities continue at unacceptably high levels, long term basic research is difficult to defend. But that research may hold the key to our future success.

The other necessary ingredient might be closer at hand. Over the last five years, the body of available data has grown exponentially. The need now is to use that data. To develop a framework that can help guide us.

The human factors research requires resources. The data analysis requires wisdom. Both are available to us and both commodities must be applied if we are to achieve meaningful reductions in crash frequency.

Mr. VALENTINE. Thank you, sir.

Mr. Saxton.

Mr. SAXTON. Thank you, Mr. Chairman, and members.

I'm Lyle Saxton, of the Federal Highway Administration, and on behalf of FHWA, we certainly appreciate the opportunity to present our views at this hearing on advanced vehicle highway technology and human factors research.

Mr. Richard Morgan, our Executive Director, had a major prior commitment and he sends his regrets at being unable to testify before you today. He has, however, prepared a statement for the record on this important subject.

[The prepared statement of Mr. Morgan follows:]

Statement of Mr. Richard D. Morgan
Executive Director
Federal Highway Administration
U.S. Department of Transportation

Hearing Before the Subcommittee on Transportation, Aviation, and Materials
House Committee on Science, Space, and Technology

on

Advanced Vehicle-Highway Technology and Human Factors Research

June 7, 1989

Mr. Chairman and Members, the Federal Highway Administration (FHWA) appreciates the opportunity to present our views at this hearing on advanced vehicle-highway technology and human factors research. As we approach the 21st Century, a thoughtful consideration of existing and developing highway transportation needs in the U.S. must conclude with the intent to place major program emphasis on operational improvements. The fundamental objective of the highway system is to provide mobility--and to do so in the most efficient, safe, and environmentally benign manner. As the highway system has evolved and matured in the past, emphasis has appropriately been on putting the basic physical plant of roads in place. Now the Nation must seek ways to better, more effectively use this existing highway and street system.

Existing operational problems are of serious concern and future trends appear almost overwhelming. For example, an existing two billion vehicle hours of delay annually on the Nation's urban freeways are a tremendous loss of resources and detract from the quality of life; nearly one thousand fatalities per week throughout the Nation are unacceptable; and air quality problems in almost one hundred major cities are quite serious. Solutions to these problems will not come easily, nor will they be simple monolithic answers. To deal with congestion, for example, broad aggressive programs incorporating development of new technology, application of current best practices, new construction, and demand management, as required, are essential. Similarly, broad multi-element programs will be required to improve safety and air quality.

Description of AVHS

It is against these growing operational problems and their challenge to the viability of our highway transportation system, that Advanced Vehicle-

Highway Systems (AVHS) technology appears particularly promising. Sometimes referred to as intelligent vehicle-highway systems or smart vehicles and smart highways, AVHS systems have been broadly grouped in four areas.

- Advanced Traffic Management Systems (ATMS)--which monitor the flow of traffic, adjust signal timing, and manage freeway operations to provide for the most effective movement of traffic.
- Advanced Driver Information Systems (ADIS)--which provide traffic, safety, and trip-related information to drivers within their vehicles using both visual displays and/or auditory techniques.
- Heavy Vehicle and Commercial Operations (HVCO)--which use advanced systems to improve their efficiency of operations and compliance with regulatory requirements.
- Automated Vehicle Control Systems (AVCS)--which automatically control vehicle steering, speed, and headway to improve traffic flow, safety, and trip predictability in both urban and rural locations.

It must be emphasized that these four system groupings overlap and the full benefits of mature AVHS technology will require the integration of these four component systems into an overall highway transportation management system. AVHS benefits will accrue to both urban and rural areas, to the individual as well as collective society, and to all age groups of drivers. AVHS will also assist in providing the efficient highway transportation system which is vital to our economy and international competitiveness.

To better understand the promise of AVHS, I have sketched five brief scenarios which describe a few of the many examples of how AVHS can benefit the highway system both now and in the future.

1. Example of Advanced Traffic Management Systems:

   You are driving on a major city street with signalized intersections. Although traffic is moderate, you are progressing smoothly from block to block when you encounter a queue of vehicles ahead of you which is slowing due to a minor accident ahead. Like the majority of drivers, you turn onto a side street to get to a parallel street that will bypass the problem. Although this route on side streets would normally be given very little signal green time, you note the green time has been

increased to accommodate the increased flow of traffic. This "real-time" responsiveness to changing traffic conditions is a primary feature of intelligent highway systems and some real-time control capability is presently in use.

2. Advanced Driver Information Systems:

You are driving on a major freeway and encounter heavy traffic. You check your in-vehicle information display and see congestion exists for the next 3 or 4 miles. The display shows there is a parallel major street which is free of congestion. At the next off ramp, you exit the freeway onto this street and continue to your destination.

Parenthetically, I would add that more advanced future versions will be able to actually direct motorists to their destination via the most direct or least time route. These advanced driver information systems rely on the traffic management systems of my first example for the real-time information on existing traffic conditions.

3. AVHS for Commercial Operations:

You are driving a commercial long-haul truck. In the past, you periodically had to stop at inspection facilities where State inspectors checked your vehicle's weight and safety condition, your permits and log books. Fortunately, you are now equipped with the latest in advanced technology equipment, including on-board sensors and automatic vehicle identification. This advanced equipment transmits the required information ahead to the inspection station and, if all is in order, you proceed without any delay or stop.

4. In-Vehicle Safety Advisory and Warnings:

You are driving in foggy weather with poor visibility on a rural primary road. You miss seeing the fixed roadside warning sign of the dangerous intersection ahead or the upcoming sharp curve; however, your in-vehicle information system provides you an auditory and visual display of this important information. This is the same system that will also warn you of potentially hazardous conditions which vary with time or move from location to location such as a lane striping or mowing operation. This system can also replicate all essential signing information in the car to augment the legibility problems that develop with the aged driver.

5. Intercity Travel:

Finally, in the future, you must travel a few hundred miles between two cities. With growing travel demand and congestion in all modes, you are glad you can make the trip in your new high-speed, automatically controlled vehicle. These automated routes are being extended throughout the U.S. and are providing a new level of high-speed travel that is very safe and reliable. They also provide an outstanding level of service even under reduced visibility weather conditions which generally cause a wide variation of speed and more dangerous conditions on conventional highways where vehicles are under manual control.

Mr. Chairman, these five simple scenarios are intended only to describe a few of the possible opportunities for AVHS to substantially improve highway operations both now and in the future. Clearly, we are on the threshold of a new generation of highway operations when we develop and deploy this technology.

Present Status of AVHS

Let me briefly describe the status of AVHS development in the world. Internationally, there are several substantive efforts underway involving both government and industry. In Europe, these include the PROMETHEUS program, organized primarily by the European auto industry, and DRIVE, a major collaborative R&D program supported through the European Community (EC). The combined financial commitment to these two efforts has been stated at approaching $1 billion. In Japan, several system development efforts are underway primarily involving advanced driver information systems.

While not on the scale of the European or Japanese efforts, there are activities in the U.S. underway at the universities and in the private sector. In addition, the FHWA has focused part of its existing traffic operations R&D budget on AVHS--principally advanced driver information systems. The cooperative experiment called "Pathfinder," involving Caltrans, General Motors, and FHWA, is the most publicized of these present activities. Pathfinder is an initial experiment to provide real-time traffic conditions and navigation information to motorists within their vehicles, using both visual and auditory displays. The experiment consists of 25 equipped cars and will be performed in the Los Angeles area.

At the State and university level, there are four AVHS-related programs underway. California has the most substantial, working through the University of California at Berkeley. Texas, through the Texas A&M University, and Michigan, through the University of Michigan, and the Massachusetts Institute of Technology also have initial program efforts underway.

U.S. industry certainly has many activities which are associated with AVHS-type systems. For example, the Etak Corporation in California presently markets a vehicle navigation system; General Motors is involved in several projects; and there are fleet management vehicle location and communication systems commercially available with others under development. Also, Motorola has established a group for AVHS-type ventures and others are seriously examining AVHS market opportunities.

Research Priorities

Your invitation requested comments on research needs and priorities. The Department of Transportation is currently developing programmatic recommendations in this area as part of a report to Congress on Intelligent Vehicle-Highway Systems which was requested in the FY 89 DOT Appropriations Act. To assist in the preparation of the report, the Department has issued a discussion paper and established a docket for comments. Comments have been requested by June 15 and the docket number is 46284. The FHWA has been working closely with other DOT offices on this report and has developed some preliminary thoughts on these questions. Our primary goal of AVHS is to operationally deploy and use these promising systems to improve highway operation. Thus, we believe emphasis should be on research plus development and demonstration. Also, it is important to realize the various technology and systems identified as part of AVHS are at different stages of development and deployment availability. Considerable technology is currently available for deployment today--such as in freeway, signal, or corridor traffic management systems. For example, present freeway surveillance and control technology can significantly improve the ability to monitor freeway traffic conditions, detect and respond to incidents, and improve mainline traffic flow. While there are a few cities with excellent systems in operation, there are many more which presently do not have modern freeway management systems.

Even in more advanced concepts such as advanced driver information systems, the majority of the underlying technology is currently available and lacks only the synthesis into effective system configurations. However, future advanced systems such as automated vehicle control do require more substantial research of the related technology and control issues. Thus, our perspective of an AVHS program is one characterized by a set of parallel, but integrated efforts which are in different stages of development and deployment availability. To be successful, an AVHS program must yield a continuous set of interim results which can be deployed while parallel development and demonstration efforts on longer range systems are also vigorously pursued.

There are, however, at least two broad research and development needs common to most AVHS systems. Broadly, these can be classified under human factors and systems design. Human factors research has been an important part of previous highway programs to match highway design, including geometrics, signing, and traffic control devices to the motorist. Clearly, there are substantial new human factor research questions associated with AVHS, including motorist interfaces with in-vehicle motorist information systems and partial and future full automated control. It seems possible that we are at the initial stages of a long-term evolution which could eventually see the majority of present roadside-located messages provided to the motorist from within the vehicle. I do not forecast this in the next 10 years, but clearly that trend is consistent with the future direction of technology and motorist information need. Thus, the complete spectrum of human factors questions must be responsibly considered. AVHS systems are likely to alter the driving task in major ways and it is essential these changes stay consistent with individual driver needs and capabilities. To ensure that we continue to improve the quality and safety of the driving experience, we must address human factors problems in very early system design stages. Questions to be considered include method of message presentation, message priority, effect on driver safety, and message structure. These issues specifically relate to the design and location of in-vehicle displays and controls, diversion of driver

attention problems, information overload, older driver needs, user acceptance, and driver interaction with other on-board systems. The National Highway Traffic Safety Administration (NHTSA) shares concern in this area and we are cooperating with them on specific research activities. My colleague from NHTSA will discuss human factors research in more detail.

Another major R&D priority will be to design the most effective system configurations for AVHS. As mentioned, the majority of the necessary supporting technology of computers, micro electronics, and communications are available. But we would emphatically note, there are still major system problems and questions which must be dealt with if these systems are to be successfully deployed. Let me cite three examples of system design issues: (1) what is the recommended communication link between the vehicle and highway consistent with the enormous numbers of vehicles, present radio frequency spectrum demands, and the state-of-the-art of technology; (2) what is the overall system architecture which integrates the vehicle and highway elements of AVHS into the most cost-effective system; and (3) what are the necessary standards and specifications which will assure standard interfaces and commercial interchangeability while not limiting innovation or commercial opportunity.

One approach for dealing with these preceding issues would be a national cooperative program to develop, demonstrate, and deploy AVHS. Such a program could be the source of reliable, consistent funding and should involve government and industry in cooperative, partnership activities. Responsibility for various AVHS activities would recognize the respective roles of government and industry. For example, the Federal Government's interest includes standards, safety, and regulatory issues while seeking overall improvements to highway operations. Industry would presumably focus on the design, manufacture, and marketing of hardware systems and components. Industry-government partnerships would not necessarily require a pooling of financial resources, although this should be encouraged where beneficial to the parties, but they should strongly encourage cooperative, coordinated

activities where the different parties are responsible for agreed upon program elements. A simple example is the present Pathfinder project mentioned earlier where each of the three parties, FHWA, CALTRANS, and GM, have agreed to perform specific activities which, in the whole, result in a meaningful project.

AVHS Implementation

Mr. Chairman, you also asked for comments on the implementation of AVHS. This may be one of the most challenging hurdles. Many of the generic implementation issues confronting AVHS include the same broad but critical problems affecting future highway transportation in the U.S. One of these is the growing shortage of skilled technicians, engineers, systems installers, operators, and maintenance personnel that are an essential underpinning of even more simple traffic signal systems. A second will be the need for adequate funding for both capital costs as well as operation and maintenance costs. A third basic issue is the vast assortment of jurisdictional responsibilities at the operational level. AVHS will cover broad geographic areas and must transcend local jurisdictional boundaries. This may require the many local agencies and jurisdictions in an urban area to establish an operating organization which is empowered to act on behalf of all parties to gain the maximum benefits from AVHS.

There are also implementation issues specific to AVHS. A very important one will be the need for adequate interface specifications mentioned earlier. These specifications will also assure motorists that the AVHS systems onboard their vehicles will work nationally, not only in their home area. Finally, successful implementation will require public support for AVHS. This will require a sense of the value or benefits of such systems by the public and the individual user. We believe the best way to both successfully develop AVHS and also establish this consumer interest and demand may be through operational demonstrations in selected locations throughout the U.S. as it is being done with the Pathfinder program. These operational demonstrations are considered an essential program element of any possible national program. An important feature of these demonstrations would be to enhance the transition from development to deployment by involving the maximum cooperative

participation of industry and State and local government. Not only does this cooperation familiarize these parties with the system, it imparts a responsibility for getting the most from these systems and making sure they are not just interesting R&D projects.

Coordination

Involvement of all appropriate public and private partners will certainly require effective coordination. To assist in these initial formative stages of a potential AVHS program, the FHWA has been participating in an informal coalition known as Mobility 2000. This group has evolved over the last 2 years and is composed of representatives of Federal and State government, universities, and private industry. Their common denominator is either an active program related to AVHS and/or conviction that AVHS is an essential element of future highway operations. Mobility 2000 has worked very effectively to informally coordinate U.S. activities and assist in developing objectives and program perspective.

A more formal coordination process will be needed, however, if a substantial national program emerges. The form and mechanisms of such national coordination are still in the formative stages, but clearly, certain features should be included. These include meaningful coordination with all parties especially industry, State and local government, and universities. Also, the capability for joint ventures between the Federal Government and these private partners should be considered.

Conclusion

Mr. Chairman, in conclusion, we would like to again emphasize the need to aggressively pursue all means of dealing with present and developing highway operational problems. FHWA believes advanced vehicle highway systems have excellent promise. The deployment of those technologies which prove effective will help provide a highway transportation system in the 21st Century which is characterized by improved mobility, safety, and quality of service for the motorist.

Thank you, Mr. Chairman and members of this subcommittee for the opportunity to provide these comments.

Mr. SAXTON. As noted, I am his Assistant for Advanced Technology Systems and would like to provide a brief slide presentation which summarizes some of the key points of his statement and also describes in a little more detail the R&D project known as Pathfinder.

So if I may, Mr. Chairman, slides.

[Slide.]

The fundamental objective of the highway system is to provide mobility and to do so in the most efficient, safe and environmentally benign manner. As we look back on the 20th century, we can be very proud of the excellent highway system which we, as a nation, have put in place.

[Slide.]

However, as we approach the 21st century, a thoughtful consideration of existing and developing highway transportation needs in the U.S. must conclude with the intent to place major program emphasis on operational improvements.

[Slide.]

Current operational needs are of serious concern and future trends appear almost overwhelming. For an example, almost 2 billion vehicle hours of delay take place annually just on our nation's freeways and such delay is a very, very clear and tremendous loss of resources, both to the individuals, as well as to the nation.

Nearly 1000 fatalities per week throughout the nation are unacceptable and air quality problems in almost 100 major cities are quite serious.

[Slide.]

It is against these growing operational problems and their challenge to the viability of our highway transportation system that advanced vehicle highway systems, or AVHS, appear particularly promising. These systems have been broadly grouped in four areas, which I will briefly describe on the four following slides. These are the generic titles that we use of those four areas.

[Slide.]

The first area is advanced traffic management systems. These are systems which monitor the flow of traffic, adjust signal timing, and manage freeway operations to provide for the most effective movement of traffic. Future systems will be even more responsive to rapidly changing traffic conditions and will presumably also interact with individual motor route guidance systems like Pathfinder in years ahead.

[Slide.]

These advanced driver information systems are a second major area of considerable interest, and as the slide somewhat depicts in the upper right-hand corner, you can see a CRT-type presentation of an electronic map of the area.

These systems will provide traffic, safety and trip-related information to drivers within their vehicles, using both visual and auditory display techniques. These systems, of which Pathfinder is an early generation, may lead to significantly better use of existing highway capacity and improved motor safety.

[Slide.]

The third area deals with heavy vehicle and commercial operations. These are systems which will use advanced technology to

improve their efficiency of operations, as well as compliance with regulatory issues. These systems, of which the HELP project, which some of you may be familiar with, which is in the western Rim States—the HELP project is a primary example and, as such, by using this technology, the truckers can reduce wasted time and improve their overall fleet management.

[Slide.]

This somewhat futuristic artist's conception of an automated vehicle control system is one which, in the future, may automatically control vehicle steering, speed and headway to improve traffic flow, safety and trip predictability, both in urban as well as rural locations. These systems, although the most advanced and complex, also offer the most opportunity for truly substantial future improvement to the highway system.

It must be emphasized that these four systems—of these four previous slides—really overlap considerably and the full benefits of a mature AVHS technology will require the integration of these four component systems into an overall highway transportation management system.

I would just add parenthetically that in the full text, approximately five scenarios are briefly described which give you an even better understanding, hopefully, of how these types of technologies can be applied and the benefits that would be achieved to the transportation system.

[Slide.]

Mr. Chairman, your invitation requested comments on research needs and priorities in AVHS. At least two broad research and development needs have been identified involving systems design issues and human factors.

[Slide.]

Let me cite three examples of system design issues. One, what is the overall system architecture which integrates the vehicle and highway elements into the most cost-effective system, something that we always have to examine very studiously.

Two, what is the recommended communication link which will combine the vehicle and highway consistent with the enormous numbers of vehicles, present radio frequency spectrum demands, and the state of the art of technology?

And three, what are the necessary standards and specifications which will assure standard interfaces and commercial interchangeability while not limiting innovation or commercial opportunity?

Returning to human factors, clearly there are substantial new research questions associated with AVHS, including motorist interfaces with in-vehicle motorist information systems and possible partial and hopefully eventually future full automated control.

AVHS systems are likely to alter the driving task in major ways and it's essential that these changes stay consistent with individual driver needs and the capabilities of drivers.

[Slide.]

Let me digress now and provide a little more information on Pathfinder.

[Slide.]

Pathfinder is a current example of research and development which we are involved in which addresses some of these very basic

research questions that we just mentioned in the area of advanced driver information systems. Pathfinder is a cooperative project and is making an initial assessment of how this technology can be used to assist the driver in congested freeway locations.

[Slide.]

Pathfinder will use a TV-type display which presents a map of the surrounding streets to the motorist.

[Slide.]

In Pathfinder, a commercially available navigator system will be modified and a communication link to the car added so that the display will also show the traffic condition information in the area surrounding the motorist and allow him or her to make choices as to which route they want to take.

[Slide.]

In Pathfinder, the experiment will consist of 25 vehicles and will be performed in the Los Angeles area. We're very proud to point out that this is a cooperative experiment and one that involves both Federal Government, State and industry. And in that connection, Federal Highway is responsible for doing the experiment design, pulling together the equipment and providing a system that is debugged and ready to go to California. California will actually perform the evaluation and do the detailed assessment and General Motors is providing the 25 vehicles, as well as some human factors consulting.

[Slide.]

Pathfinder will be operated in what is called the "smart corridor," which is an area some 15 by 5 miles around the Santa Monica Freeway in Los Angeles and includes not only the freeway, but the parallel and major arterials in that network. Indeed, the idea of Pathfinder is that drivers, if they are on the freeway, as an example, and run into a lot of congestion or a major incident, would be able to look at their display and see if there is available capacity on one of those major arterials that parallels it and if so, then divert and take the arterial.

[Slide.]

In operation, data is collected from a number of different sources. There are detectors in the freeway and on the streets. There is information that will come from the police, and from construction and maintenance crews. This information will all be sent to the central computer, which will combine it, integrate it and provide data information back to the equipped vehicles in the Pathfinder cars, which will then be displayed as an overlay on that particular visual CRT.

I might note that it also provides for text that can be written on the bottom of the CRT on specific incidents and there will also be an audio display, such that synthesized voice messages can be provided as well.

[Slide.]

The project schedule for Pathfinder—we are under way. Last September, 1988, the experiment began in a formal sense, a contract has been let for the part of this that the Federal Highway Administration is responsible for. We currently are doing the experiment design. The vehicle that you will see this afternoon, after lunch, if you choose and have the opportunity and time to do so, is

one of the first two prototype vehicles that has the equipment installed in it and will be one of the vehicles that will eventually be used as part of the 25 in the actual experiment.

We expect to do the pilot testing by December of this year and the formal testing would then start approximately in March of this coming year. The experiment will run approximately a year in duration, although there's some thoughts that we may expand that because there's considerable other interest in using this.

[Slide.]

Mr. Chairman, in conclusion to these short comments, Federal Highway again would like to emphasize the need to aggressively pursue all means of dealing with present and developing highway operational problems.

We believe advanced vehicle highway systems have excellent promise. The deployment of those technologies which prove effective will help provide a highway transportation system in the 21st century which is characterized by improved mobility, safety and quality of service for the motorist.

Thank you, Mr. Chairman, and members of the subcommittee, for the opportunity to provide these comments.

Mr. VALENTINE. Thank you, sir.

Let me ask, first of all, each of you, or both of you, if you would—I know this might be a little—a little bit beyond the scope of what we are here about today. If so, and you would prefer not to answer this question, then I would certainly understand, but in the statements that have been made, particularly the statements by Mr. Finkelstein, as I understood it, the emphasis was placed, of course, on the ability of the individual operating the automobile, and that so many accidents were the result of poor judgment or some other problem which was directly the fault of the man or woman who was driving the car.

Are you able to tell us what effect the increase in the speed limit has had on that problem? You know, the Congress took steps which—the result of which the speed limit was increased—increased the maximum limit from 55 miles an hour to 65 miles an hour in many parts of the country.

Mr. FINKELSTEIN. We've been tracking the events since the speed limit was increased in April of 1987. What we have seen is a sizable increase in fatalities, on the order of 18 percent in 1987, and the 1988 data is just starting to come in. It looks like there was no decline, the rate of increase in fatalities has continued to rise, but not nearly at the same level.

The increase in fatalities occurred almost exclusively on highways where the speed limit was increased. Now, I say "almost," because there were some States where the speed limit was increased and the fatalities on those roads declined. But looking at the 38 States, I believe it was, which, by the end of 1987, had raised their speed limit, there was at least an initial increase in fatalities.

We do not yet know whether that will decline; whether that is a short-term transitory effect or what will happen in the long term. We are continuing to examine the crash statistics as we collect that data and we're starting some work right now, in fact, to examine changes in average speed on those roads.

I think the preliminary funding—the preliminary data—indicates that there is certainly a change on those roads—it was limited to those roads, but there were enough differences among the various States that it's hard to have an absolute conclusion as to what's occurred.

Mr. LEWIS. Mr. Chairman?

Mr. VALENTINE. Mr. Lewis.

Mr. LEWIS. Yield please for a moment?

Mr. VALENTINE. Yes.

Mr. LEWIS. Mr. Finkelstein, did you or the data that you observed increase in fatalities on the highways where the speed limit was increased—did you take into consideration the increase in miles driven on that highway since the last data was assimilated and also the number of vehicles on the road compared to the previous period?

Mr. FINKELSTEIN. Yes. We tried to. We did and the increases in travel—there were increases in travel across virtually all of the road systems. The increases in travel were slightly higher on the interstate system in that year than on the other road systems, but the increase in travel appeared to be rather consistent both in States that raised the speed limit and States that did not raise the speed limit, if my recollection serves, if my memory serves.

So we tried to factor that in and we—most of the analysis was based on comparisons of what happened on those—on rural interstate highways compared to what happened on other road systems, and other rural systems and the analyses are continuing. We have a number of State universities that are trying to examine the information in more detail to look at larger data sets, to look at things like crash involvements and not just fatalities to try to get a better understanding of what has, in fact, been occurring.

Mr. LEWIS. But you did take into consideration—

Mr. FINKELSTEIN. Yes, sir.

Mr. LEWIS. —the additional vehicles that are traveling on those roads in relationship to the previous benchmark and when the last data—

Mr. FINKELSTEIN. Yes, we did, sir—

Mr. LEWIS. —was taken?

Mr. FINKELSTEIN. Yes, sir.

Mr. LEWIS. Thank you, Mr. Chairman.

Mr. SAXTON. Mr. Chairman?

Mr. VALENTINE. Yes.

Mr. SAXTON. If I might comment, perhaps a plug for advanced technology in this regard a little bit. So much of the time when we talk advanced technology or these advanced vehicle highway systems, the context becomes one of urban congestion and so forth and obviously that's extremely important. But I think that as we look somewhere into the future at partial automation and full automation, looking at that technology, that there are many of us who see that as perhaps one of the most direct ways of dealing with some of these issues of safety and fatalities.

We know that there is a very large problem that we have in the manually driven vehicle in the variation of performance capability of the individual driver, their driving styles and it's one of the

things that obviously you wonder how in the world you can ever to come to grips with under the present system.

I'm not trying to suggest that you're going to have automated highways on every road everywhere at all times, but certainly as that technology becomes available, and even eases into it in partial automation, one could look at safety as being one of the major benefits.

Mr. VALENTINE. What period of time would it—would be required, do you think, to—for you to conduct a—a study that would give us reasonable accurate information on—as to the question that I have raised about speed? I mean, are we talking about an examination of statistical information over a period of two years, three years, five years?

Mr. FINKELSTEIN. We will be doing that and that hard thing to predict is when the data stabilizes to the point where you're able to conclude that what you're looking at is a steady state. For the early and mid- '80s, fatalities annually on rural interstate highways were somewhere on the order of 2000 to 2100.

They initially have increased after the rise in the speed limit. Whether they revert to former levels or whether they stabilize at some new level, it's just a function of how long it takes for the data to settle down, and one of the things that has happened is that there has been a very great deal of variation among the various States where the speed limit had been raised.

Right now, the data show the rate of increase is declining. It has not yet stabilized, so it would be hard to tell how long it will take. We will be reporting by the end of the summer—I think in September, we expect to have our analysis of the full 1988 calendar year data completed, as well as some of these studies that have been conducted by a number of State universities for us.

Mr. VALENTINE. I don't—we have a hearing scheduled on that question sometime, I think, in July, so I don't want. to take a lot of time on that. If you would let us have a copy of these findings—

Mr. FINKELSTEIN. Certainly.

Mr. VALENTINE. —we would certainly appreciate it very much, addressed to this subcommittee or the full committee.

I have one or two more questions and then I'll move on to our colleagues, because I certainly don't want to monopolize the limited time that we have here.

I—a couple of these slides—one of them indicated you directed the attention—our attention to the upper right-hand part of the picture and I saw there what appeared to be a television screen of some kind, and then there was another close-up of that screen. Is that—that would be part of the equipment installed in these automobiles and that—whatever—whatever advantage it would provide the operator—and I don't question that that would be manifold, that is something else for the driver to do, isn't it—

Mr. SAXTON. That's correct.

Mr. VALENTINE. —in addition to paying attention to the road in front of him, because you're talking about equipment that is—is installed in a vehicle that still has to be driven, not one that fastens onto a beam and is pulled on like the tail of a comet, so to say, so that—what do you say about providing the problem with providing the driver something else to do, some other place to look, some

other—you can't look at the road ahead of you and look down at that screen.

Mr. SAXTON. Clearly, you're quite right, and as the human factors professionals speak of the driving process, they talk about loading, the point being that you have a number of tasks that the driver's performing at any point in time and, as you get into more complex—

Mr. VALENTINE. I was going to ask you a question about the consumption of alcohol. When you say "loading," you're not talking about that, okay.

[Laughter.]

Mr. VALENTINE. But I didn't want—I will come back to that maybe if we have enough time. Excuse me. Go ahead.

Mr. SAXTON. Terms fit across the board, don't they?

Mr. VALENTINE. Yes.

Mr. SAXTON. But clearly, this is an area that there is concern about. We have been doing some research studies on this already. General Motors, by the way, has conducted a number of research studies looking at precisely this same element.

The—the sense here is that in the initial results that we have, that it is not a problem for navigational purposes or route guidance, that the driver tends to chunk the information. In other words, he will glance down if he is in a situation where there are a lot of other things that he needs to be paying attention to. He'll simply glance at the screen, glance back to the roadway, glance again, and through this periodic glancing, maintain the information that he needs to know.

On the other hand, if it's a less stressful situation, then he may look a little longer at that screen. But regardless of how this turns out, there's a whole series of human factors issues that relate to these in-vehicle driver displays.

One of the thoughts here that we're examining is the use of audio backup such that in more congested and more difficult driving situations, in addition to the visual display, the driver will actually get a speech-synthesized type message that will provide that same general information to the driver.

So there's other ways that we're looking at as well. We hope that it turns out that the use of these displays can be done very safely because we do feel that there's an awful lot of potential benefit of providing information to the driver directly in the car through these displays.

Mr. VALENTINE. Thank you, sir.

I'm advised that our colleague, Mr. Brown, has another appointment and has to leave, so I will recognize him at this time for a question.

I'll say to other members of the subcommittee, if you have a similar problem, we will take you out of turn, also.

Mr. Brown.

Mr. BROWN. The chairman is very kind. I do apologize, but I have to leave shortly.

Gentlemen, this committee's jurisdiction, as you know, really relates to your research development function primarily, and you have been asked, I gather, to comment on your research needs and priorities and that you're doing that as part of a major report on

intelligent vehicle highway systems mandated by previous legislation. Is that correct?

Mr. FINKELSTEIN. That is correct, sir.

Mr. SAXTON. Yes, sir.

Mr. BROWN. It may well be that that report will answer all of our questions, but it's my personal view that your agencies, in common with a number of other rather prosaic, but very important agencies, are underfunded in terms of research and development.

I think one or both of you comment that the Japanese and the European efforts are substantially ahead of us in some of the new technologies here, as they are in some other areas, I might point out, but this is a highly undesirable situation.

What this committee should be and is interested in is how we can maintain an adequate, robust, competitive research program, an advanced technology development program. We're not talking here about your agency competing with National Science Foundation to support basic research, but the key to improvement in this country in all aspects is consistent, sustained, targeted efforts at improving on what we already have. And that includes the highway system, the automobile system, every other aspect of the system, the human factors aspect, and what I would like to request you to include in your report, if you are not already planning to do so, is to give us some idea of the scope in terms of money and on a historical basis, if possible, of your overall research and technology development effort; how that compares, at least in some indicative way with the European and Japanese programs, and what level of resources we might be talking about that would put us back in a competitive posture, because we don't want to see our economy continue to suffer from inadequate attention to these efforts.

We don't want to see our quality of life continue to suffer because of continued failure to devote sufficient resources to this area and I would like to see this committee, in fulfilling its own mandate, to exercise overall governmentwide oversight of the health of our established—our research and technology establishment—to have this kind of information so that we could make some appropriate recommendations as it involves your agency.

Is that a—a request that you would be able to fulfill?

Mr. SAXTON. In fact, it is the intent of the report to Congress to have programmatic recommendations and that would include funding levels.

Mr. FINKELSTEIN. Yes, sir.

Mr. BROWN. And, of course, I'm sure you gentlemen know that there's a certain interaction between your efforts and other government programs. One or both of you indicated that sometimes what you need is not new technology or new science, but it's a better-focused effort at what we sometimes call technology transfer.

Mr. FINKELSTEIN. Yes, sir.

Mr. SAXTON. Yes.

Mr. BROWN. For example, in the military, the battlefield commanders want real-time satellite observation of the battlefield. Southern California's a battlefield, believe me—

[Laughter.]

Mr. BROWN. —and we need real-time overhead observation of what's going on there and it's not difficult to get if we decided that

that would make a significant improvement in the way we manage traffic in southern California. It's the utilization of technology that might develop in one area to meet the needs in another area that is your real problem. I think that we need to focus on how we can do that.

Thank you very much, Mr. Chairman, for allowing me to raise that point and make those observations.

Mr. VALENTINE. Thank you, sir.

Mr. Lewis.

Mr. LEWIS. Thank you, Mr. Chairman.

Mr. Finkelstein, in your report or presentation, you pointed out with the European program that over 100 automotive suppliers and 70 research institutes are involved, plus all the leading European-owned car companies, are involved in this program, and then you mention on the next page that in the program here we have the Department of Transportation, Ford Motor Car and Radar Control Systems.

Are all our major car manufacturers in the United States involved in this program at all?

Mr. FINKELSTEIN. No. We have pieces of a program. We are starting to examine—we have projects under way, I think would be a more accurate characterization. We have a Pathfinder project that is looking at an application of a specific kind of technology to the—to congestion relief. We have the project that we're involved in with the California Department of Transportation to look at obstacle detection technology to see if that can be applied to convoying vehicles.

We have this overall group, this Mobility 2000 group that has been sharing information and discussing whether or not there should be a program and exchanging information, but there's really—there does not yet exist a program in the United States that has as its goal the application of advanced technology to an enhanced motor vehicle highway system.

Mr. LEWIS. What have you found as your driving force for the Europeans to move ahead like this in such a consolidated method and we find sort of a scattered method here in the United States?

Mr. FINKELSTEIN. I think two things occurred. The first thing that occurred was that with the United States was increasing its investment in advanced technology research with military applications and that was excluding a number of the European companies, the European community came up with a program to subsidize collaborative research among companies in Europe that were dealing with the civilian applications of electronics.

It was called the EUREKA program. I'm not sure what the acronym stands for. They do a much better job than we do of acronyms.

Mr. NAGLE. They're better than us in that?

Mr. FINKELSTEIN. EUREKA.

Mr. VALENTINE. We need to have those people over here.

Mr. FINKELSTEIN. I'll tell you.

So they had a framework in which governments were willing to collaborate with companies, and the second thing that they had was they had a few people who had a vision of—and an interest in developing this coordinated program, principally at Mercedes-Benz, the Daimler-Benz researchers had very major electronics programs

advancing and were trying to involve governments throughout Europe to somehow make sure that as their products were ready to go to market, they were useful, and that the highway system, and the transportation structure was available. The Mercedes-Benz researchers managed to convince the 12 or 13 other major auto producers in Europe and they came together with this program. This is a joint program.

That $800 million number is probably one-third government, two-thirds industry, so it's a very major kind of an effort that we, in the U.S. transportation sector have no experience working on. We don't have a framework through which we approach those kinds of issues yet.

Mr. LEWIS. Have you seen any interest generated in recent years with our American manufacturers in this area?

Mr. FINKELSTEIN. There are germs of interest. There are some companies that—there's a lot of activity. There's a lot of consideration being given. Companies—well, like General Motors will be testifying later today. They probably have been the American auto producer with the greatest interest in pursuing efforts of this kind.

But we collectively have not yet figured out how to organize that interest and whether or not we even need a national program of this kind. Those of us who make our living in research, obviously, are looking for a means to get this thing organized, but we have not yet succeeded in even describing it clearly enough so that people would be able to say yes or no to it. That's hopefully what this report to Congress can succeed at doing, can define what a program should look like and what some of the institutional choices are.

Mr. LEWIS. I think that's a very interesting comment. I'm interested in the European program because, as you mentioned, it's like two-thirds private sector, one-third government and over here, we seem to reverse that particular formula, and we expect the Federal Government to provide the basic research and then the industry to take it over at a later date.

It would seem to me, to avoid the steel-mill type of syndrome, that we should be looking at industry itself taking the lead in these areas and not expecting the Federal Government to take the lead.

Do you feel that we—yes, sir?

Mr. SAXTON. I wonder if I might comment also, Mr. Lewis.

When we look at the potential program in the United States, it's been made very clear, I think, on the part—especially through this Mobility 2000 that involves industry, universities and our government at State, Federal and local level, that it's got to be a real partnership type of operation.

There are industries, as have been mentioned here, Motorola, GM, and a few others, who have seen perhaps the bigger picture and they talk about AVHS in the sense that here's a program that's going to marry vehicles and highways and, you know, how do we get involved and what's our role in it.

AT&T is an example of this, looking at some issues in that same regard, but perhaps what gets left out at times is that there's a number—a larger number, in my judgment—of companies that are involved in specific technology that directly relates to this AVHS but actually have not become involved and have not looked at it

from the broader national or system sense. They're looking at it more from their own component technology or for their own particular specific application.

An example might be the IImorrow Company that's tied in with UPS. In fact, UPS actually purchased them and is building capability for fleet management using a lot of this electronics for their own commercial needs. So I think one wants to also realize that there is a whole—a very broad base of other industry players and activities that are going on that perhaps don't normally get counted when we say, "Well, what's happening in AVHS in the United States today?" At some point, if a national program did develop, I think it would coalesce these interests rather strongly and I think one could see that there'd be a strong industry base, as well as government and user base for that type of technology.

Mr. LEWIS. The question I was going to ask, then, do you both think that we need a national transportation policy?

Mr. SAXTON. Our Secretary certainly is putting us to work to get one and it seems like it would be very fitting.

Mr. LEWIS. Do you think it would help in the research and development area in forming consortiums, Mr. Finkelstein, in order to move ahead?

Mr. FINKELSTEIN. I think if we could focus—if we can provide some targets, it may be possible. There are certainly consortia forming in other areas and we—this is not an area where—it is unreasonable to expect we'd be able to seed development.

Mr. LEWIS. I'd like to ask you one more question. Thank you, Mr. Chairman, for your indulgence.

What approach did the Department use in order to get the universities and industries and other government agencies together, as well as the other sections of the private sector, together in order to move ahead on a program such as this?

Mr. FINKELSTEIN. I think the credit probably belongs to the California Department of Transportation and the University of California at Berkeley. Mr. Walker was describing the transportation in California and those of us who live in other parts of the country look at the congestion in California and see it occurring in more and more places around the country.

The University of California and Caltrans organized the appropriate actors. They convened a number of meetings with the Federal Highway Administration, the National Highway Traffic Safety Administration, other universities and people involved in the automotive industry and the electronics industry and this sort of ad hoc coalition grew into this Mobility 2000 group, which, frankly, Lyle Saxton has been doing most of the work to hold it together.

So California deserves a great deal of the credit for initiating the effort and the Federal Highway Administration deserves a great deal of the credit for keeping in on track, I think.

Mr. SAXTON. I think if you sort of stand back a few paces and look at the big picture in terms of all the things we're describing, the fact that there are highway needs that are not being met, operational needs, especially, that there's technology that's becoming available that gives us tremendously additional capability over what we've had in the past, and it just seems, in my judgment, that these various opportunities are coalescing at, I think, universities,

industry, and at the government level. Users of the system are starting to see that perhaps now is the time to take advantage of this happy marriage, if you will, that can make some significant improvements to the highway operation or the operation of the highway system.

And it's—it's not any one constituency, particularly, but I would suspect that as we go into the next year or so, looking at what the highway program should be over the next five to 10 years, that we'll hear more and more about just this subject of AVHS and how it's going to fit into dealing with the problems.

As I said, I think it comes from a very broad base of interest and participants.

Mr. LEWIS. Thank you, Mr. Chairman.

Thank you, gentlemen.

Mr. VALENTINE. Thank you, sir.

We have with us today our colleague, Mr. Dave Nagle, of Iowa, who is a member of the Science Committee, but not a member of this subcommittee. However, we are delighted to have him here with us, and without objection, extend to him the opportunity to participate in these proceedings.

David.

Mr. NAGLE. Mr. Chairman, I want to thank you, first, for holding this hearing and your continued effort in the problems of highway transportation and traffic safety. Secondly, I want to thank you personally for extending me the courtesy to participate in these hearings, even though I'm not a member of your subcommittee.

I can assure you, should I in 20 or 30 years ever get to be a subcommittee chairman, I'll extend to you the same rights.

[Laughter.]

Mr. VALENTINE. Thank you very much.

Mr. NAGLE. Doctor—Dr. Finkelstein, I was curious—oh, one other footnote, Mr. Chairman, if I could, of housekeeping. I would like to submit a statement for the record at a later date.

Mr. VALENTINE. Without objection.

[The prepared statement of Mr. Nagle was not received at press time.]

Mr. NAGLE. Of course, we've been looking at the—some aspects of this at the University of Iowa, an institution that I have the good fortune to represent, and I noticed on page 5 of your statement, you said, "Critical to the success of human factors research will be projects to develop and validate research and analytic tools to obtain data, protocols for assessing potential safety degradation or benefits of intelligent vehicle systems and decision aids to support choice of research and agency actions.

"We are currently working through the National Science Foundation with the University of Iowa to examine technical and economic feasibility of developing a state of the art driving simulator."

My first question, just for the record, is what is a driving simulator?

Mr. FINKELSTEIN. A driving simulator is a tool that places a human being, a driver, in an environment that is intended to fool him so the individual thinks he is driving. It would have a car; it would have a visual display that represents the driving scene; it would be on a platform that was movable so that in response to

whatever the driver did in the vehicle, he would experience the same sort of sensations of driving.

The uses of a driving simulator are obviously to conduct research that's repeatable, that can place drivers in high-risk situations without obviously exposing them to any danger.

It's used in aviation; it's used in the Defense Department for tank operations; and it's used elsewhere in the world for development of—for the conduct of driving research and automotive safety research.

Mr. NAGLE. Do you need a driving simulator? Would the ideal model be to have a driving simulator in conjunction with some of the other research that's going on, such as intelligent vehicles and safety management?

Mr. FINKELSTEIN. We have some driving simulators in this country. The ones we have do not provide the capabilities to allow you to examine new technology very effectively. When we—the reason we're conducting this feasibility study, in fact, is to arrive at some of those decisions, to see how much simulation capability is needed, how much we can afford, who would be interested and what kind of research programs would be used to—if such a simulator existed, but when one looks at the range of technology that's available and when one looks at our abilities to measure the physical performance of the vehicle on the road, we don't yet know how to interpret all of those measurements. We don't yet know how to apply them and the difficulty that one has without a driving simulator is you either have to mount very expensive long-term field studies or you have to make a lot of guesses.

In some of those cases, you really can't do either because you have a very serious risk of either exposing drivers to hazardous situations, to overloading drivers in traffic with new technology, and we need some tools, and whether it's instrumented vehicles, whether it's better body of laboratory research or whether it's driving simulators, we need to develop those tools if we're going to make the advances that we should be able to make.

Mr. NAGLE. If we had a driving simulator, we would—just trying to extrapolate from what you've just told me—you would be able, then, to actually test these designs and these systems before you actually had to put them into a car.

Mr. FINKELSTEIN. Yes, and more than that, you could test them much more efficiently. It's important to realize that while I began my testimony with sort of a citation of the number of fatalities and injuries that occur, for the most part, the driving task is a safe task. There are a lot of crashes, but the reason there are a lot of crashes is because there is so much driving that goes on.

When you run a fleet study, even a sizable fleet study, and you're looking for changes in safety performance, you need thousands and thousands of equipped vehicles on roads. It gets very, very expensive to just get the basic data.

It's very difficult to pursue research that allows you to examine more than one or two treatments; so even once you've come up with something that works, the center high-mounted stoplight is on vehicles today as a result of two large-scale fleet studies that we pursued. We had 2000 vehicles in each fleet. It took a year and a half of on-road performance and that enabled us to determine that

the addition of a light in the rear of a car that gave an additional indication of braking did result in a reduction in rear-end collisions.

But we by no means believed that we were able to optimize the performance, optimize the design or come up with the best regulation possible because we didn't really understand everything that was working. What we were able to learn from that study—those studies—was that that kind of relatively inexpensive addition to a vehicle could reduce crashes.

If one had a simulator that could replicate those kinds of driving tasks, one could do a much, much better job of designing the best system possible and one could short-cut those studies by years and years, I would think.

Mr. NAGLE. There is, I understand—I have been informed, and of course, you would be better informed, there is one driving simulator in existence right now of an advanced nature. I think that's at the Mercedes-Benz—

Mr. FINKELSTEIN. Yes, sir.

Mr. NAGLE. —in Europe, is there not?

Mr. FINKELSTEIN. Yes. The Mercedes. There are a number of more advanced driving simulators in the world than exist in this country. The Europeans have a number of simulators that are much more advanced. The Swedes have a more advanced one; Volkswagen has a more advanced one, but the world class driving simulator right now is the one developed by Mercedes-Benz in Berlin.

We've been recently using it in cooperation with the German Government on a study to examine drugs and driving safety. There's a project we've been pursuing to just examine—to develop dose-response information on drugs, what level of antihistimine in the driving population, for example, sufficiently degrades performance that people ought to be worried about it, that we ought to be able to intervene.

I know the Germans are going to be using the simulator to do some work on aging drivers, which obviously is a problem that is just not exclusively a German problem, but it's a problem nationally when—

Mr. NAGLE. Does it have some impiications, though, in terms of looking at another aspect of this, along with efficiency and speed at which research projects can be done and the validity with which you can do research projects with a good simulator? Does it give their European car manufacturers a competitive edge over ours? I mean, can you incorporate designs into these things, major designs?

Mr. FINKELSTEIN. That's the reason Daimler-Benz built it. Obviously, there are—there are world-class cars being built everywhere on this planet without it, but a number of companies in Europe are making large investments in simulation technology with the purpose of having an influence on their product development. So at least they think so.

Mr. SAXTON. Mr. Nagle?

Mr. NAGLE. Yeah, I'm sorry, yes.

Mr. SAXTON. One comment—that there is a very minimal driving simulator that is located out at the Turner Fairbank Research Fa-

cility, a part of the Federal Highway Administration here at Washington, D.C. It's been there since about 1983. Even with its elementary capability, we've been able to perform a number of studies that have been very, very useful and points out the value of these in terms of looking at some of the safety issues, some of the driver perception issues.

Most of the new signs, as an example, that are different and are going to be something that most motorists haven't seen, we will run those through that simulator and get an initial assessment. The problem with that particular simulator is that basically it does not have any motion system and it does not have the brightness to give you anything other than a sort of nighttime-type scene.

The point of what I was going to mention as well is that in looking at the technology that has come along, there are ways of upgrading these devices at reasonable cost and we're trying to put together some sort of a program that, over a couple of system generations, will upgrade this to a considerably better facility. But our experience to date has argued very, very forcefully for the need for these types of simulators.

Mr. NAGLE. I would think that. I would be a little concerned. I note—you know, competitiveness is a buzzword, but setting aside efficiency, setting aside a savings, setting aside cost, setting aside time, if they can build their next generation of automobiles off simulation and we have to build ours on trial and error and guesswork and, you know, I don't mean bad engineering principles or good engineering principles, but that's—it has its limitations.

From a competitive standpoint, where is the American automobile industry going to be if we don't have an advanced simulator?

Mr. FINKELSTEIN. Well, certainly, anything that one could—well, you've got witnesses from at least General Motors, I know, appearing later today. It will be interesting to hear their views on it, but certainly one of the most important competitive issues today is the speed with which you can bring product to market.

Studies of the Japanese industry show that that's their real strength, that they can develop new product much more quickly than any North American company has been able to do today.

Mr. NAGLE. Let me take a side note. What are the Japanese doing in this area?

Mr. FINKELSTEIN. They're not nearly as advanced, which is the interesting issue. We just had a meeting overseas and there's some work going on in Japan with it, but it's not nearly as advanced as the work going on in Europe right now.

Mr. NAGLE. Now, to go ahead and complete, if you would, my question, if we don't have a simulator and they do have a simulator, other automobile manufacturers, foreign auto manufacturers have a simulator and we don't, does that place us in a competitive disadvantage from the standpoint of our automobile industry?

Mr. FINKELSTEIN. I would think it has to. I would think at least there are a whole range of product development issues that we will not be—that our manufacturers will not be able to address as completely as companies that have those tools available.

Mr. NAGLE. Now, quoting from—and I appreciate the indulgence of the chairman and the committee members, quoting from your testimony at page 6, "The national research development and dem-

onstration effort for IVHS' programs is warranted. A strong organizational framework would be needed to bring together the public and private interests in this area."

Would that statement include the development of a simulator should we decide that it was feasible and practical and affordable to do so?

Mr. FINKELSTEIN. It certainly could. The French Government right now is developing a national driving simulator with their interest in pursuing their manufacturers' competitiveness and developing these kinds of programs.

Mr. NAGLE. I think—and I don't mean to lead you, but one of the problems, of course—we can do an aircraft simulator, an air flight simulator without a great deal of difficulty because the variables are more controllable, but the ability to develop a ground simulator, ground-based vehicle simulator, would seem to me—would require a—would provide an opportunity for use not only by the automotive industry, not only by highway safety planners, not only by people concerned with smart vehicles, but I think it would have implications for NASA, would it not? It would have implications for DOD.

Mr. FINKELSTEIN. The areas that seem to be most relevant get into areas like—are driving, but driving issues are not necessarily vehicle-related issues, issues like drugs, issues like impairment, issues like an aging population.

One of the things that we keep talking about is the driving task, the things that drivers must do, and we keep talking about the driver and there's not a driver. There are 130- or 140 million drivers and the range of skills and abilities represented in that population is the range of skills and abilities that our system has to be able to address.

Mr. NAGLE. And you can't build an experimental car for each one of them.

Mr. FINKELSTEIN. Well, it'd be awfully expensive. That's what we may have to do. It's not clear. That's why we do large-scale statistical studies of how the traffic system performs now.

Mr. NAGLE. Let me then drive to my last point again, if I could.

Then, is it your judgment at this point, and I recognize that much needs to be done, but is this an area where the Federal Government has a role in the development of a simulator to cover the wide variety of needs the simulator can provide and the wide variety of factors that a simulator would have to be adapted to or should we just simply leave this to the private sector and hope that GM does it? Or Ford or Chrysler?

Mr. FINKELSTEIN. Well, if a simulator existed, there's an awful lot of public sector research that we do in our agency that would be moved onto a simulator, wherever it was. It would take the research—we would certainly try to be major users, so if a simulator were to be developed, it would be a simulator that we would hope would be publicly accessible. But it would—it's something that we could use. It's something that is very expensive and, given the scale of the programs that we've been involved in over the years, it's just been much larger than the kinds of programs that either the Federal Highway Administration or my agency has ever sort of had—has ever looked at.

Mr. NAGLE. Would it be an appropriate area for the pooling of resources of the Federal Government and the private sector, to develop this type of a vehicle—or this type of—

Mr. FINKELSTEIN. It seems—it strikes me that that would be a good model, that this is a tool that a lot of people would like to get some experience with. American manufacturers don't have ready access to simulators elsewhere in the world. Certainly we don't have ready access to simulators of this scale elsewhere in the world and if we could pool—certainly, pooling of resources strikes me as the most rational way to pursue it.

Mr. NAGLE. Now, is it Dr. Saxton—I can't—there's a chair in front of you—Mr. Saxton.

Mr. SAXTON. Mr. Saxton, Lyle Saxton.

Mr. NAGLE. Well, it's doctor this morning. Do you want to add or amplify on anything Mr. Finkelstein has said?

Mr. SAXTON. Well, again, just to point out that our experience in Federal Highway research has been to find these simulators very, very valuable. They're not an end in themselves. The way we use them is, really, you can sort of think of it as a narrowing down of your options because we start out typically—in a lot of the work—just dealing with subjects and showing them different signs or different messages or different driving situations to try and get a feeling as to how they would respond. Then we'll take it to the simulator and refine that set of what appear to be good potential solutions and, of course, then the next step is to go out in the world and do your final testing under the total real-world conditions.

So we have found it to be very, very useful. Our view is that regardless of what happens on this area of AVHS, that the normal traffic operations and safety research that we have been involved in really needs a better simulator, a much better simulator, and our objectives are to try and go towards that in one way or another.

The problem in some of these simulators is that there is not just a single simulator design. The automobile manufacturers typically are looking for something that very, very faithfully reproduces the dynamics of the vehicle, and so that gets into a particularly exotic design of the motion base and so forth.

Our application is looking more at the motorist and how he behaves in a highway operational setting and, as such, we can get by with less fidelity on the motion system, but we need more fidelity on the visual system. So there's more than one way that these things come out.

Mr. NAGLE. But we know where they come out if we don't have one.

Mr. SAXTON. That's right. We definitely need that type of device.

Mr. NAGLE. Let me thank you. Thank you both for your answers and let me thank the chairman and the members of their committee for their indulgence. I obviously have an interest in this. I confess that, but I think it's valuable and can stand on its own merits.

Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, sir, and I hope it won't take you 25 years.

[Laughter.]

Mr. VALENTINE. Mr. Rohrabacher.

Mr. NAGLE. If I keep asking questions as long as I did, it may take longer.

[Laughter.]

Mr. ROHRABACHER. Well, with all respect to my distinguished colleague, we do have simulators already, don't we, and in terms of being able to test people for the impairment in terms of drug use or impairment in their need for—and how it affects their—how they can drive a car, we've already got machines that can test that, don't we?

Mr. FINKELSTEIN. No, we don't.

Mr. ROHRABACHER. We—I mean, I was just over at the video game parlor the other night—

[Laughter.]

Mr. FINKELSTEIN. The question that you've got needs more than a yes/no answer if you want to deal with issues of highway and motor vehicle safety. What you're looking at is a realistic assessment of what levels of performance change result from changes in technology, changes in highway design and the like, so whether you need—how far up the technology scale one has to go before you get a usable one is obviously—

Mr. ROHRABACHER. I just can't help but believe that when the government is doing something like this, that we're going to end up building a machine, if we go into—if the government goes into the business of building the machines like this—that will cost $100,000 in order to—in order to build a machine that in order—which we could buy a $15,000 car and put them out in the back lot and get the same testing out of.

It just seems to me that that sort of common sense is often lost on people who are advising government programs and trying to build technology through the government—government programs for these types of ends.

And, of course, automobile simulators really aren't as necessary as aviation simulators, are they? I mean, the fact is with a pilot, when he makes a mistake and is—you might think that that's justified to test a pilot up there as he's going up there at 25,000 feet versus somebody who's on the back lot of—you know, driving the car around a course, and it's not quite as dangerous for the guy driving the automobile because he can put on the brakes, versus the pilot who's up at 25,000 feet.

Mr. FINKELSTEIN. We killed 47,093 people in 1988 on our highways. I—

Mr. ROHRABACHER. That's not answering the question. That has nothing to do—

Mr. FINKELSTEIN. Well, the answer is no, I don't agree with you. I think that the issue—

Mr. ROHRABACHER. You think there is a fundamental similarity between testing a pilot and testing driving reaction in—

Mr. FINKELSTEIN. No, I—

Mr. ROHRABACHER. —the sense that you can't test—you can't test a driver, or you have to test the driver in the same way you test the pilot—

Mr. FINKELSTEIN. No, I think—

Mr. ROHRABACHER. The pilot is—even though the pilot is up in an aircraft and a car you can drive just right around on the ground—

Mr. FINKELSTEIN. It's a question of what you're testing for. If you're trying to determine how a change in a vehicle is going to affect the operation of this highway system and its safety, then the answer is you need some way to expose those drivers to risk, or at least that's my opinion, that you need to expose them to some risk. You have to approach limited conditions and the difficulty doing that—

Mr. ROHRABACHER. And the current simulators don't do that?

Mr. FINKELSTEIN. No, they do not.

Mr. ROHRABACHER. Okay. I mean, I don't know if you've been to the arcades lately, but I've got to tell you that whoever designed these computer systems that you get in there and you start driving around, I mean, they didn't have to do it with a multi-million dollar government program either. And I bet they're making a profit at it, at that.

The—what was the—what profits did the—our auto companies make this year? Do you know? Do you have any idea what our three major auto makers made in profits this year?

Mr. FINKELSTEIN. The last numbers I saw were in excess of $3 billion and I think that may—I don't know if that was for the quarter or for the year? A lot. They had a good year.

Mr. ROHRABACHER. So they made $3 billion and you still think it probably is necessary to have a government/private sector program in order to develop things that will make our industry profitable?

Mr. FINKELSTEIN. I think the question is do I think that we could do a better job of highway safety research in the public sector if we had access to such a facility, yes. Do I think that the government needs to make large-scale investments to help make the automobile industry more profitable, I don't think so.

Mr. ROHRABACHER. Okay.

The—by the way, in terms of research that is necessary in order to make the roads safer—it doesn't surprise me after driving around in France, that the Europeans are trying to automate driving of their own drivers. I mean, for those of you who are going to be going to the Paris Air Show, you don't have to go to the Air Show to see the Frenchmen flying through the air. I mean, these people drive—I mean, I am a Californian and I'm—so—in terms of technology and how it's going to—and I've very aware of the highway system, the freeway system and the congestion problem we have in California. I mean, this is a real problem in California. That's where I come from and I'm not—I mean, I don't take it lightly.

But—I mean—I think technology can offer a lot of solutions, but don't you think—a lot of solutions to a lot of problems we face in America, but don't you think what we're really talking about is a need for capacity and not a need for a change in technology?

Mr. SAXTON. Well, you certainly are. I mean—you know, the statement has always been made, and I think it's kind of like one of the standard underpinnings of everything we do, that there's no substitute for just basic raw capacity.

Mr. ROHRABACHER. That's right.

Mr. SAXTON. If you can go out there and if you can put that into place, granted, in the rural areas, they have no problems because they have tremendous excess capacity. I think the problem becomes one that—when you start finding that there's a limit to any additional freeway miles, lane miles or arterials that you can put in, and, of course, that is very quickly what you encounter in any built-up urban area.

Then the question is, well, how do I maximize the flow through that network and use whatever capacity exists? In other words, balance out my flow so that I can take advantage of it.

It's interesting to me, and I—I will say that I know this is only a couple of trips, but being involved in this Pathfinder and driving on the Santa Monica Freeway, you can look over many times when the freeway is stop and go and look at some of these arterial—parallel arterials—

Mr. ROHRABACHER. That's right.

Mr. SAXTON. —and see a lot of spare capacity.

Mr. ROHRABACHER. That's correct.

Mr. SAXTON. Now, you say, well, what does that mean? Does that mean that the motorist on the freeway has checked his time and he realizes that he can make just as good a time with that stop and go and he just doesn't want to get off and hassle with those side streets or has he just not particularly tried them? But the point is—

Mr. ROHRABACHER. Or perhaps the powers that be have not had a concerted campaign to make sure the traffic did flow on that unused capacity.

Mr. SAXTON. Could be as well.

Mr. ROHRABACHER. Like, for example, coordinated lights so that people could get off the freeways, rather than—well, anyway, so they could get off the freeways and use that capacity.

Mr. SAXTON. Yes, so that is what you're talking about. So that's the point of Pathfinder or this type of technology, to show that driver, who has a particular destination, where the congestion exists and give him the choice to get on the roads that presumably will flow more easily for him.

Now, clearly, when you use up all your capacity, you know—I mean, let's say that we've done this. We've got all this technology out there and we have a car on every 100 feet or every 50 feet of roadway and it's all nicely distributed. I mean, at some point, you cannot create brand new capacity just electronically.

Mr. ROHRABACHER. Well, there are ways to create capacity even in Los Angeles. I mean, people—without raising taxes. I mean, we're dedicating, I think, a new double-deck system. We're starting it out there in Los Angeles this weekend. It's the 50th anniversary of the freeway system in southern California, this year, and as far as I'm concerned—and this is totally germane, but the fact is, we could double-deck the freeways. We could actually—if we'd like, we could do it on borrowed money and then pay—make the top deck a toll road, for that matter, and pay back the borrowed money out of people who are willing to pay to drive on the upper decks at a faster pace, as far as I'm concerned, rather than raise everybody's taxes, but, of course, everybody seems to want to look at taxes as a source of solving every problem that exists in the world today.

My last question, I guess, would be just basically the automobile companies, and we—just to touch on what we did before—the automobile companies are making a lot of money. They're making a lot of money this year, and if we're going to build something, whether it's a automobile simulator or whatever, I mean—you can give me your reaction to this—basically, if they're going to make a profit off something in the long run because it's going to help them design their cars better, when they're making $3 billion of profit, maybe it's time that they—and they would probably do a better job at designing something for their own needs and using that money out of their profits rather than coming from the taxpayers. What would be your reaction to that statement?

Mr. SAXTON. Well, it's got to be an integrated system and even the choice of the title, you know, vehicle highway systems, I think, implies that. And there is very definitely an area that is industry's interest, responsibility, and I think there is an area where there is a government interest, not just necessarily Federal, but certainly State and local, because the two complements—there are smart highways and there are smart vehicles and the smart highway gets into things like the traffic management systems, which has clearly been a public responsibility in the past and will be in the future, as is the operation of the signal systems, your freeway system, the publicly owned systems, if you will, and the real trick here and what has probably sort of caught on here is the fact that now you're trying to integrate or blend more and more the operation of the vehicle with its onboard equipment to what is in the highway.

But clearly, the equipment that goes into the vehicle, the selling of that equipment, design of that equipment, that would certainly, in my judgment, at least, be an industry function and the important thing is that we work very closely together in that regard.

Mr. ROHRABACHER. It's a very good answer. Thank you very much.

Thank you, Mr. Chairman.

Mr. VALENTINE. Mr. Walker, ranking member of the full committee.

Mr. WALKER. Thank you, Mr. Chairman.

I'll get to another question here in a minute, but you quoted a figure here a few minutes ago, 47,093 deaths on the highways. How many of those were on rural interstates?

Mr. FINKELSTEIN. About 2500.

Mr. WALKER. About 2500 of those were on rural interstates.

How many of those were on rural interstates in States that have a speed limit of 55 miles an hour?

Mr. FINKELSTEIN. I'd have to provide that, but I believe more than 80 percent, because most States have, by this time, raised their speed limit to—

[The material referred to above follows:]

Mr. Finkelstein: The table below presents the 1987 rural Interstate fatality count, distributed between the 10 states that retained the 55 mph and the 38 states that increased the speed limit to 65 mph. These data were in the January 1989 report to Congress "The Effects of the 65 mph Speed Limit During 1987."

1987 Rural Interstate fatalities in the 10 states that had a 55 mph speed limit	313
1987 Rural Interstate fatalities in the 38 states that had a 65 mph speed limit	2,191
1987 Total rural Interstate fatalities	2,504

Note - two states, Alaska and Delaware, do not have rural Interstate highways

Mr. WALKER. Yeah, but most—but the—most of the populated States haven't. Well, not most, I shouldn't say, many of the populated States haven't.

Mr. FINKELSTEIN. But they don't have that many miles of rural interstate highway. If you look—

Mr. WALKER. Pennsylvania does, for example.

Mr. FINKELSTEIN. Pennsylvania and New York are the two States that do have substantial rural interstate—

Mr. WALKER. Yeah, and a significant, as I understand it, a significant number of that 2500, in fact, are on that. I mean, of that 2500, at least 500 of that are—are from States where—

Mr. FINKELSTEIN. It's still at 55—

Mr. WALKER. Still at 55.

Mr. FINKELSTEIN. That would be my estimate as well, that it's about 80 percent and 20 percent.

Mr. WALKER. So, we're talking—we're talking something in the vicinity of 2000 deaths that occur on rural interstates where the speed limit is 20—is 65.

Mr. FINKELSTEIN. That's correct.

Mr. WALKER. What percentage of those are a result of drunken driving?

Mr. FINKELSTEIN. Probably 40- to 50 percent.

Mr. WALKER. So probably 1000 are something other than drunken driving.

Mr. FINKELSTEIN. Yes.

Mr. WALKER. What—what percentage of those occur at speeds less than 65 miles an hour?

Mr. FINKELSTEIN. On those roads, probably relatively few. Most—

Mr. WALKER. That's not the information I have. The significant percentage of—of the accidents that took place involved cars moving at less than the—than the 65-mile-an-hour speed limit.

Mr. FINKELSTEIN. I think that the average—the data that we have on the average speeds, in terms of the crashes that are involved is that most of the travel—and most of the crashes that are occurring are occurring at relatively high speeds on those roads, which is not a surprise, but one of the problems, of course, on any road is the disparity in speeds, as well as the actual upper limit of the speed, and the average speed is contribution to the lack of safety.

Mr. WALKER. And also, of course, there are a number of other things. I mean, how—how much are we looking at, for instance, lane discipline? I mean, what I'm getting at is there is a significant amount of stupidity—

[Laughter.]

Mr. WALKER. —that enters into this whole thing. I mean, before we start off with the premise often on these things that speed kills, the fact is that what really kills on our highways is stupidity.

Mr. FINKELSTEIN. Well, driver errors kill. Eighty percent—

Mr. WALKER. Yeah, well, and much of that driver error is based on stupidity. I mean, it is people who are either driving a car faster than what their skills allow them to drive—

Mr. FINKELSTEIN. Uh-huh.

Mr. WALKER. It is people who are driving a car—I mean, I passed—I passed a woman driving at 65 miles an hour the other

day—and I don't mean this as a comment on women drivers; it just happened to be a woman driver—I was coming down the road; we were doing—we were doing about 60 miles an hour and she was reading a book. Had it propped on the steering wheel and was reading a book on the Baltimore Beltway.

Mr. VALENTINE. Let the record show that stupidity is a factor.

[Laughter.]

Mr. WALKER. The reason—the reason why I make—the reason why I make the point is at the very most, we have 1000 deaths out of 47,000 that might be somewhat attributed to a 65-mile-an-hour speed limit.

Mr. FINKELSTEIN. No, most—many crashes have more than one cause and the thing that we're examining—at least in our assessment of the speed limit studies, is the situation—for example, you cited drunk driving. Drunk driving is occurring on roads all over the country. The thing that we are looking at and that we don't have a complete answer to, Mr. Walker, but what we're looking at is the change that has accompanied the change in the speed limit, all things being equal.

Unfortunately, there's far too much drunk driving that goes on on all road systems and the differences between—the thing that's the most interesting to us is the fact that there are some States where, in fact, they raised the speed limit and fatalities declined.

Mr. WALKER. Uh-huh.

Mr. FINKELSTEIN. There are some States where they—we still don't—the reason we don't have a complete answer yet is because we're still looking at State-by-State variation and trying to come up with some assessment of what is happening and why it's happening.

Mr. WALKER. But my point is, the fact is that in a properly constructed car, with a person driving with proper driving techniques, speed does not kill. Isn't that true?

Mr. FINKELSTEIN. I don't know what that means. I—

Mr. WALKER. No, crashes kill.

Mr. FINKELSTEIN. If you don't crash, you don't get killed.

Mr. WALKER. No, no. But that's—that's not—that's not wholly true. We've tried to keep people from crashing, but all of America watched the other day at the Indianapolis 500 where a car came—went into three pieces and so on at 200 miles an hour; the driver got out and walked away from the—from the crash. He was in a properly constructed car; he was—he was going at very, very high speeds; the car crashed and so on, and he walked away without a scratch.

Now, what I'm saying is that in that kind of—in an appropriate kind of environment with appropriate kinds of techniques and with appropriate kinds of measures being taken, speed does not kill, and one of the problems that we have in our society is that we—we do not have cars which are properly constructed. We do not have cars which are—we do not have drivers which are properly trained, and we do not have situations where the highways have been properly constructed to handle the speeds.

But what I want to get to is the point you made in—in your testimony. You say here, part of the reason for our limited understanding of the contribution of human factors to crashes is great difficul-

y in conducting human factors research safely under controlled and repeatable conditions, and then you go through a bunch of things about visual performance and—and all of that.

I found that all very interesting because I just came back from three days in a school where we spent our time doing nothing but all those kinds of things. And so—and I would have to tell you, what you say here is absolutely wrong when you say we do not know what specific visual capabilities are required, what measures of visual or cognitive workload are meaningful or what measures and criteria of acceptable driver performance should be used to conduct research.

It's being done in schools all over the country practically every day of the week. Are we using any of that research?

Mr. FINKELSTEIN. The research that we're talking about is research being applied to the specific tasks of driving and—

Mr. WALKER. This is specific tasks of driving.

Mr. FINKELSTEIN. Well, then I would—I certainly would—

Mr. WALKER. They're training race drivers.

Mr. FINKELSTEIN. I would be very interested in being advised of that program and seeing if we can learn from it.

Mr. WALKER. They're training race drivers all over the country. There are—there are schools all over the country doing that. There's a guy by the name of Bernal Ruse up at Pocono International Raceway in Pennsylvania that specifically uses what he calls "occular driving techniques" in training people and he specifically can quantify everything you say in here that can't be quantified.

He say—he can specifically quantify the—how visibility from a—a vehicle is requisite for safe driving. He—he has written a textbook on it.

Now, what I'm asking is, is any of that being—being utilized? Obviously, from the testimony, none of it is.

Mr. FINKELSTEIN. We have got some of the best researchers in the country working on that issue now and—

Mr. WALKER. Are any of them using the—the material that's being developed almost daily in places where they are sending—sending people out. Ruse can take you in a car—he has simulators.

Mr. FINKELSTEIN. Yes.

Mr. WALKER. He can take you in a car that's called a slide car and so on that literally changes—that literally changes with every braking motion, every steering motion and so on and puts the car into a slide.

Mr. FINKELSTEIN. Uh-huh.

Mr. WALKER. And so he literally can change—tell you—show you with visual techniques how you can drive a car going sideways up the road—

Mr. FINKELSTEIN. Uh-huh.

Mr. WALKER. —because when the car goes into a slide, he changes—tells you how to use your eyes in order to keep that car on the road and not take it down into a ditch somewhere.

Now, what I'm asking is, if we're saying that we don't have information on that, is any of the information that's being developed almost daily, like that, being—being utilized in our research?

Mr. FINKELSTEIN. We have examined that research over the years and it does not have application to the kinds of man/ma-

chine interaction programs that we have to deal with when we're interested in the performance of the overall fleet.

Mr. WALKER. Why in the world not? Why—if, in fact, he knows that 80 percent—I mean, he can give you a figure—80 percent of the ability to handle a car is based on your visual technique and he can quantify it.

Mr. FINKELSTEIN. Yes.

Mr. WALKER. Well, you say they can't even quantify. He has—

Mr. FINKELSTEIN. No, I'm not agreeing. I'm saying, yes, I hear what you're saying, Mr. Walker. I'd like to see—

Mr. WALKER. Oh, you don't agree that 80 percent of—of—of driving depends upon what you see?

Mr. FINKELSTEIN. I'm saying it's necessary to see. I'm saying that the issue we're looking at is not what's necessary to drive. The issue we're looking at is why crashes occur and what interventions are needed to prevent crashes.

Mr. WALKER. Why crashes occur is because people don't see them coming.

Mr. FINKELSTEIN. Well, we'll have to look at some of that work, because I don't think that's why crashes occur. I think crashes occur for a very wide variety of reasons and I think the issue is that what we're—we're trying to examine is we're trying to look for what is the most effective means of intervention—

Mr. WALKER. But all I'm saying to us, is there are—there are literally—there are people who are trained in this business of driving who—who understand the driving atmosphere, and so on, who are—who are in the process of teaching people in fairly high-risk situations how to handle a car safely.

Mr. FINKELSTEIN. Yes.

Mr. WALKER. You know, taking some of the risk that you referred to with Mr. Rohrabacher, and you've got people who are out doing it and what I'm hearing from you is that nobody's even bothering to look at the data—

Mr. FINKELSTEIN. I'm saying—

Mr. WALKER. —or that you're saying that the data is irrelevant.

Mr. FINKELSTEIN. No, I'm saying we—

Mr. VALENTINE. Let me—let me just interrupt a minute. You know, we—I don't want to do anything to squelch the gentleman's combatative nature and—but if you would just ask a question, please, if you could favor us by that, and give him a chance to answer. I think we'd get along better. We realize that there is some area—

Mr. WALKER. I thought that's what I was doing. I was asking—I thought I was asking a question and I was getting the wrong answers.

Mr. VALENTINE. Well, well, I can't—I mean, the gentleman's entitled to ask a question and give him a chance to answer and if you would—if you could shorten it and otherwise accommodate us, I would appreciate it.

Mr. WALKER. Well, Mr. Chairman, I will say I have sat here through a number of members who asked about 15 minutes of questions. I think that I presently have asked about 10 minutes—

Mr. VALENTINE. Well, you—I have no desire to—you just take all the time you need, sir.

Mr. WALKER. Okay, that's what I was trying—I was just trying to get some answers to some questions—

Mr. VALENTINE. Fire away. Just—

Mr. WALKER. We have testimony from a witness who says—

Mr. VALENTINE. Wait just a minute. Let's clarify this. You have—take all the time you need; just give the witness an opportunity to answer and don't badger him. Okay, go to it.

He can take care of himself.

Mr. WALKER. Thank you, Mr. Chairman.

We have—we have some testimony here, Mr. Chairman, that indicated we don't have certain information available. All I'm—all I'm asking the gentleman is why—if I know we do have such individual—such information available, that is not being used as a part of the research?

I think that's an important question to ask, particularly if we're talking about spending millions of dollars on simulators—

Mr. VALENTINE. All right, that's a question. Now you—you answer it.

Mr. FINKELSTEIN. Mr. Walker, we will look into that data, but my knowledge of the data that exists is such that I believe that while the information that people use to teach driving skills and to teach high-risk—high-performance driving is valuable for certain individuals, it doesn't bear directly on the issues that we're interested in and those issues are what general interventions can be used to reduce the frequency of crashes among the general population.

Now, I will be happy to look at that information and provide in more detail why we think it is not applicable to the tasks that we're pursuing if you would like.

Mr. WALKER. I would certainly like that, but—but what it's sounding to me like is that what you don't want to suggest is the fact that you have a lot of stupid drivers out there that might have to be retrained to—to learn how to properly drive a car and how to see the road ahead of them.

I mean, what you're saying is that you don't—that you don't want to have, as part of the development here, something which suggests that a lot of drivers need to go back to school and be retrained and we—we probably ought to have much tougher driving techniques stressed before somebody can get a license.

Mr. FINKELSTEIN. That's one of the areas that we are responsible for looking into, and you're right, that we do not produce a population of skillful drivers today on our highways.

I think I would agree with you fully on that.

Mr. WALKER. And, if in fact, we produced a population of skillful drivers, it would cut that crash rate significantly; isn't that true?

Mr. FINKELSTEIN. We've tried—yes, it would be true. We have tried to develop driver education programs and driver training programs that were effective and, to date, we have not succeeded.

Mr. WALKER. Well, but again, let me suggest to you that I'm a qualified driver education instructor—I took that in college.

Mr. FINKELSTEIN. Yes.

Mr. WALKER. What we teach in driver education is nonsense. The—you know, we provide a few hours of classroom instruction that tells people that they shouldn't drive while they're drunk, but

in terms of handling a car and going out and teaching people to handle a car, we teach them to drive the car through stanchions and that's about it.

You know, there has not been an attempt to teach people visual driving techniques in driver education anywhere in the country. Are you aware of any driver education program that's doing that?

Mr. FINKELSTEIN. Not those. We have developed much—what we thought were improved driver education programs, expanded driver education programs giving students a great deal more road time and the results of those programs were not particularly encouraging.

Whether much more expensive, much more intensive driver education programs would be worthwhile, they may—that may be the case, but then you get to the very large issue of the need to drive in a society and how much are we willing to ration people's access to highways? How much more difficult are we willing to make the driving—

Mr. WALKER. Europeans require far higher driver skills—qualifications than we do, don't they?

Mr. FINKELSTEIN. It's not clear that they have a safer driving environment than we do, though. Mr. Rohrabacher was talking about driving—

Mr. WALKER. No, no, no, wait. Now, that's not what I asked you.

Mr. FINKELSTEIN. It varies—

Mr. WALKER. What I asked you is, does—don't the Europeans require far higher skill techniques in order to get a driver's license than we do in this country.

Mr. FINKELSTEIN. Depends on what country you're in in Europe. In some countries—

Mr. WALKER. Okay.

Mr. FINKELSTEIN. —yes, and in other countries, no.

Mr. WALKER. There are—there are several countries in Europe—

Mr. FINKELSTEIN. That do—

Mr. WALKER. —who require far higher skill techniques in order to—to get a driver's license than we do.

Mr. FINKELSTEIN. That's correct.

Mr. WALKER. And it has not significantly cut the access of their people to the—to the highways, has it?

Mr. FINKELSTEIN. And it has not cut their crash involvement rate significantly, compared to the performance in this country.

Mr. WALKER. But—but you also will admit that the driving environment in Europe is—is somewhat different than the driving environment here in that many of their highways are not really as good as—as our highways in this country. I mean, that that—that that is also a contributing factor—

Mr. FINKELSTEIN. Yes, sir.

Mr. WALKER. Much narrower roads, there are—there are a lot—there are a lot of problems, although I will say that there are a number of European countries where the fatality rate is—is a good deal less than it is in this country, aren't there?

Mr. FINKELSTEIN. There's—the only—maybe since the British enactment of their safety belt use laws. The British experience may have finally gotten below ours, but if it has, that's the only country in Europe that has a safer driving environment than we do.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. VALENTINE. Thank you, sir.

Thank you, gentlemen.

Mr. ROHRABACHER. May I ask one more question, Mr. Chairman, one more quick question?

Mr. VALENTINE. We'll recognize you with fear and trembling.

Mr. ROHRABACHER. How has the accident rate been affected by the imposition of high-occupancy vehicle lanes? Has the accident rate gone up, gone down, stayed the same in those—on those highways which have had HOV lanes put on them.

Mr. FINKELSTEIN. I don't know. We haven't examined that. Have you?

Mr. SAXTON. No.

Mr. ROHRABACHER. Could you—

Mr. FINKELSTEIN. We could see if—

Mr. ROHRABACHER. —examine that and give my office a report on that, please?

Mr. FINKELSTEIN. Yes, if we can do that, sir.

Mr. ROHRABACHER. Thank you very much.

[The information follows:]

Mr. Finkelstein: According to data we have available, in 1987, eight states utilized high occupancy vehicle (HOV) facilities. They were:

1) Virginia
2) Washington
3) Florida
4) Texas
5) Hawaii
6) Massachusetts
7) New York
8) California

Although some studies have been conducted concerning the accident rates on these highways, few have addressed the comparison between HOV and non-HOV accident rates. In those studies that did compare accident rates, insufficient data exist to reach statistically significant conclusions about the difference in these rates.

Mr. VALENTINE. I thank you, sir.

Thank you, gentlemen. I yielded to my colleagues in the hope and expectation that there'd be a little time for me to ask some more questions at the end. However, all time, I think, has been consumed.

I would—we might possibly submit to you written questions on several matters as to your judgment as to the need of funding from the Federal Government in this area and also the availability, perhaps, of—to scientists in the United States as to work done in Japan and Europe, but we thank you very much and anything else we have, we'll send you questions.

Mr. FINKELSTEIN. Thank you, Mr. Chairman.

Mr. VALENTINE. The next panel consists of Dr. Ed Haug, Director of Mechanical Engineering, University of Iowa; Dr. B. J. Campbell, Director of Highway Safety Research Center, University of North Carolina and Mr. Robert E. Parsons, Director, P-A-T-H, PATH, at the University of California.

Welcome, gentlemen. We'll be happy to hear your statements at this time. The prepared statements that you have submitted will be a part of the record and you may feel free to summarize. I would recognize our Iowan, Dave Nagle, again at this time.

Mr. NAGLE. Thank you, Mr. Chairman.

Mr. Chairman, I would like to introduce one of the witnesses, Dr. Ed Haug, from the University of Iowa. Dr. Haug is a—is a professor of mechanical engineering and the Director for the Center for Computer-Aided Design at the University of Iowa, in Iowa City.

He and his colleagues have been recognized for the research in computer-assisted design and manufacturing processes and have conducted research under the auspices of the National Science Foundation, NASA and the Department of the Defense. He and his research team have been recognized for their excellence of their research in drive simulation technology by the Smithsonian Institute.

They are presently finalists in the Smithsonian's competition for the innovative use of information technology for advanced driving simulator technology.

Good morning, Doctor, and welcome.

STATEMENTS OF ED HAUG, DIRECTOR, MECHANICAL ENGINEERING, UNIVERSITY OF IOWA; B. J. CAMPBELL, DIRECTOR, HIGHWAY SAFETY RESEARCH CENTER, UNIVERSITY OF NORTH CAROLINA; AND ROBERT E. PARSONS, DIRECTOR, PATH, UNIVERSITY OF CALIFORNIA

Mr. HAUG. Thank you, sir. I suppose I don't have to introduce myself now.

I am pleased to have the opportunity to testify at this hearing. It comes, in my opinion, at a critical time in U.S. highway safety. We have a great deal of new technology that is ready and can now make marked reduction in accident rates and fatal loss of life

I would like simply to outline some of the breakthroughs in simulation technology that can first lead to human factors and vehicle design trade-off methods that will reduce loss of life, and second, provide an experimental capability to support development of vehicle and highway automation methods that can be effectively used

by our driving population, many of whom are aged or impaired in some way.

I would like, if I may, to depart from the text and use some transparencies to discuss simulator technology, about which we've had a great deal of discussion this morning.

[Slide.]

I'd like to briefly comment on what simulation technology is all about, where it is, and what we might do with it.

This is a photograph of NASA's high-end flight simulator at NASA Ames. It has 60 feet of vertical travel, 40 feet laterally, only eight feet fore and aft, in the direction of flight.

Now, it'll handle about one-half to two-thirds G of motion. A frequency of motion of about two cycles per second, which is typical of aircraft motion.

It's a good motion envelope for simulation of aircraft that's being used to design advanced aircraft, not pilot training. It's not a good envelope for driving simulation.

[Slide.]

Daimler-Benz, we've heard, has the cutting edge facility in Berlin. It is supported by a six accuator aircraft simulator motion base, with a graphics dome in which they can put the vehicle and display high-resolution graphics on the screen.

This system went on-line in 1985. It uses a single processor or a dual processor dual computer of that vintage. The motion envelope in the horizontal plane is ten feet in diameter. It covers only 81 square—or less than 80 square feet of territory. That's the only horizontal motion you can get.

It's limited to about five cycles per second of response. That's not enough to feel road harshness. The French have done studies and indicated that the dynamic resolution of this simulator, while it's the best in the world, is not adequate for critical environment experimentation.

Now, I apologize for being critical. I shouldn't. It's still a world-class facility. It's the best that exists. It's real, it works, and it'll do a lot of good things. But what I'd like to do is explain what some of the limitations are and what we can do now with the technology that exists.

[Slide.]

This is a picture out of some Daimler-Benz literature suggesting that you can—they use the simulator for stress studies in heavy traffic. I don't know if you can see it on the right, but they're showing the approach of an intersection where a car turns in front of the driver. They're using it to experiment with the visual response of the driver, how he can function with different driving aids in that environment.

The simulator is not valid in realism if the driver goes into harsh braking. It is not realistic. So this simulator cannot take him into what would otherwise be a life-critical situation. You can not do experimentation realistically in critical situations where you really want to evaluate safety aids. So it has a fundamental limitation. A lot of capability.

The graphics is good. It's CT-6 style, same as used in the aircraft simulators. This is a very bad rendition of a new class of graphics technology that uses texturing. You'd have to see the screen to ap-

preciate how realistic it is, but there is new graphics that's coming along.

[Slide.]

The key ingredient, though, that has limited driving simulation in the past has been the ability to realistically simulate the high-frequency dynamics of the vehicle so you get good road feel.

In our National Science Foundation, Army, NASA Research Center that we have at the University of Iowa, we have been developing advanced dynamics methods. For NASA, aiming at space telerobotics; for the Army, for armaments and tank dynamics; and if you can solve their dynamics problems, you can solve anybody's dynamics problems.

What's happened is that we've come up with new dynamics algorithms that are a factor of ten faster even on old machines than we had before, but they also use parallel computers, which gives us another factor of ten.

Those two factors of ten, taken with new high-speed processors that will be available in two years, give us a factor of 1000 times speed-up in computation over what was available in 1985. I would contend that's a revolution. We can now, for the first time, do realistic vehicle dynamic roadway interaction.

I view it as breaking the real-time barrier, real time meaning you're computing as fast as real clock time. It's a little bit like the airplane guys breaking the sound barrier in the early '50s.

This technology now exists and can support advanced ground-vehicle driving simulation.

[Slide.]

This is a rough artist's concept. We've been in a study now. We have some real human factors experts, best in the world by far, working with us. Our statement of requirements and technical feasibility today suggests that we want to track 90 feet long, 30 feet wide, so that we can develop extreme skid maneuvers or extreme maneuvers and turning maneuvers. The system will support motion up to 50- to 100 cycles per second, so we get all the road roughness, the ride quality, evaluation for fatigue studies.

The graphics will be this high-end, almost completely realistic graphics capability. Our suggestion is that with this system, you can indeed carry out human factors experimentation with complete realism, support vehicle development for safety and design, and bring this technology of—in some sense transfer this technology—that has been developed in the aerospace industry to the ground vehicle industry.

[Slide.]

I'd be pleased later to answer any questions you might like to pose.

[The prepared statement of Mr. Haug follows:]

Testimony For

US House of Representatives

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

Subcommittee on Transportation, Aviation, and Materials

Hearing On

ADVANCED VEHICLE-HIGHWAY TECHNOLOGY AND HUMAN FACTORS RESEARCH

by

Edward J. Haug

Center for Computer Aided Design
College of Engineering
The University of Iowa
Iowa City, IA 52242

June 1989

My name is Edward Haug. I am a Professor in Mechanical Engineering and the Director of the Center for Computer Aided Design at the University of Iowa. We are a NSF-Army-NASA Industry/University Cooperative Research Center for Simulation and Design Optimization of Mechanical Systems. Our work on dynamic simulation has recently led to breakthroughs that for the first time permit highly realistic real-time, driver-in-the-loop advanced vehicle driving simulation. I appreciate the opportunity to discuss this exciting new technology with you.

NATIONAL NEED

A key ingredient in traffic safety related human factors research is realistic driving simulation. Such a capability is required for precise measurement of driver reaction under a variety of specifically designed driving conditions, replicated enough times with enough different drivers to ensure that results are accurate and scientifically useful. The most sophisticated driving simulator, shown in Fig. 1, is operated by Daimler-Benz in West Germany. Although this facility came on line in 1985 and represents the finest driving simulator in the world, the technology on which it is based is almost a decade old. Steady advances in computer graphics and motion control technology that have come from the field of aircraft flight simulation and revolutionary advances in high speed dynamic simulation that have come from research and development in the NSF-Army-NASA Center for Simulation and Design Optimization at the University of Iowa offer major gains in driving simulation, to support both safety oriented human factors research and vehicle system design.

Recognizing the urgent national need for research on human factors related to motor vehicle safety, the National Highway Traffic Safety Administration (NHTSA) and the Iowa Department of Economic Development have provided financial resources to support a planning study to establish the technical and economic feasibility of a national advanced driving simulator. With the support of NSF and Industrial participants, an advanced driving simulator concept design study is being carried out in the NSF-Army-NASA Center. The study addresses the potential for an advanced driving simulator to (1) carry out human factors research to quantify driver-vehicle-roadway interactions, (2) support rational US policy and regulations that will lead to safer highways, and (3) support US automotive companies and vehicle fleet operators in designing and manufacturing safe, high quality vehicles. This testimony outlines preliminary results of the study.

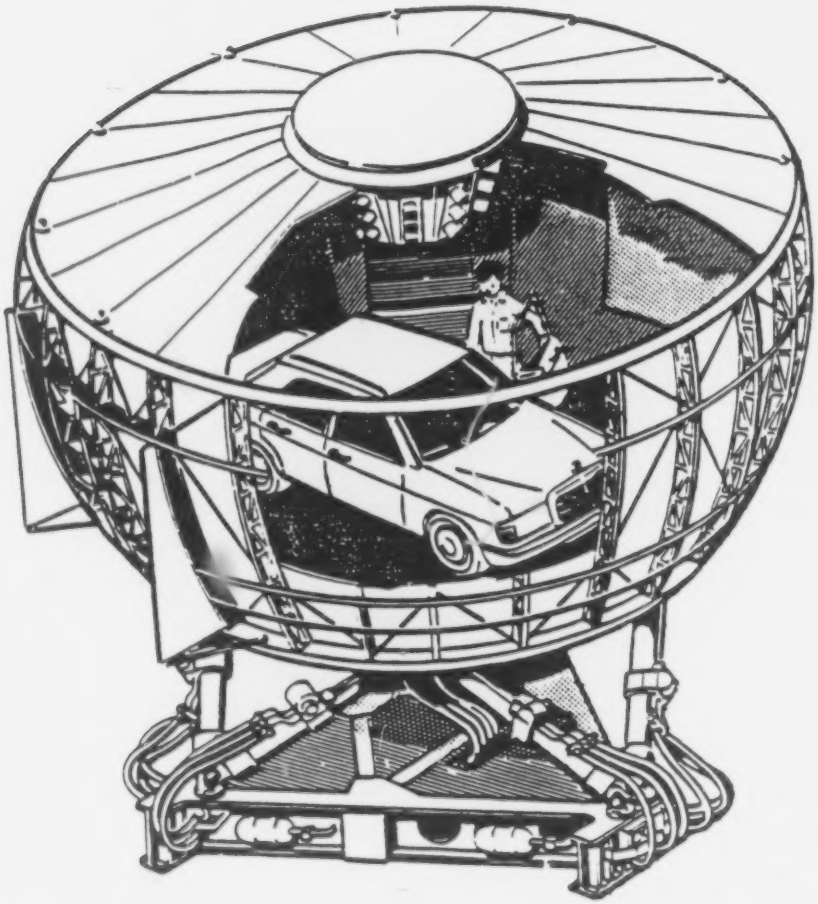

Figure 1. The Daimler-Benz Driving Simulator

BACKGROUND

Quite recently, the NASA Ames Research Center has developed large scale aircraft simulators that are used in designing advanced aircraft systems. The cutting edge flight simulator shown in Fig. 2 permits realistic motion and visual simulation of an aircraft, with the pilot in the loop. It is used in design and evaluation of aircraft and pilot assist subsystems.

While visual and motion system requirements for an aircraft flight simulator are severe, the level of sophistication of aircraft motion dynamics, in response to actions taken by the pilot, is rather modest compared to the dynamics of a ground vehicle. This is partly due to the rather slow response of an aircraft to pilot inputs. Dynamic

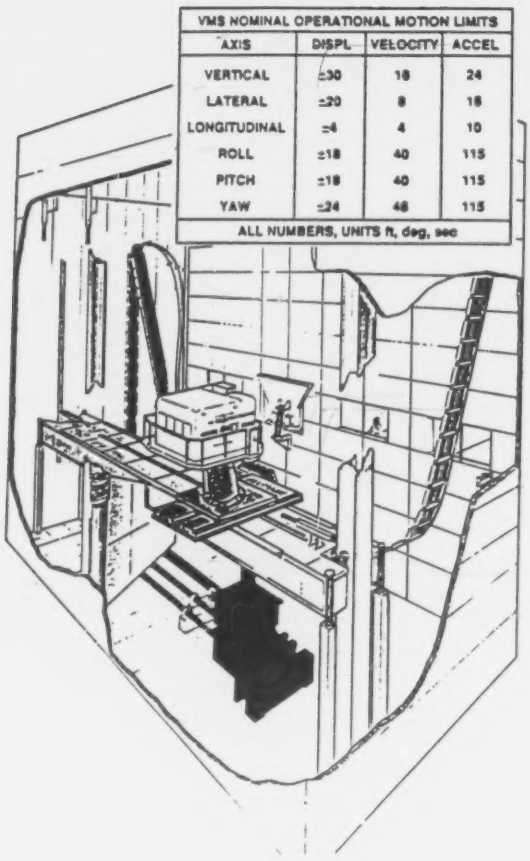
VMS NOMINAL OPERATIONAL MOTION LIMITS
AXIS | DISPL | VELOCITY | ACCEL
VERTICAL | ±30 | 16 | 24
LATERAL | ±20 | 8 | 16
LONGITUDINAL | ±4 | 4 | 10
ROLL | ±18 | 40 | 115
PITCH | ±18 | 40 | 115
YAW | ±24 | 46 | 115
ALL NUMBERS, UNITS ft, deg, sec

Figure 2. Vertical Motion Simulator

response characteristics that realistically simulate motion of an aircraft in flight involve only approximately one cycle per second of dynamic response fidelity, which is well within the capability of conventional computers. Thus, the principal technical factor that has permitted broad application of aircraft flight simulation, for both pilot training and aircraft design, is the evolution of extraordinarily powerful computer graphics visualization systems.

The extreme dynamic environment and kinematic complexities of a ground vehicle create much greater computational challenges than those encountered in aircraft flight simulation. The driver of a ground vehicle requires a minimum of five cycles per second of dynamic response in even modest maneuvers and up to one hundred cycles per second response in severe environments. Dynamic simulation of the motion of a vehicle, including the effects of intricate suspension subsystems, interaction of tires with a

variety of road surfaces, and vibration effects due to harshness of ride, requires high resolution dynamics models that are far more complex than those needed to represent the motion of an aircraft.

The first serious attempt at a high fidelity driving simulator was launched in the early 1980's by Daimler-Benz in Germany, with the support of the German government. They created a six degree of freedom motion base driving simulator, but with horizontal movement restricted to a circle of 10 feet in diameter and yaw motion severely restricted. A sophisticated graphics system generates high quality graphics feedback to the driver. In order to carry out vehicle dynamic simulation using computer technology of the early 1980's, however, simplified vehicle dynamics models were used. By a recent account of performance of this system, the dynamic response resolution of the Daimler-Benz simulator is only approximately five cycles per second, which is only borderline effective. Experience reported by study participants from NHTSA and the automobile design industry, confirmed by a recent French study, is that the Daimler-Benz simulator demonstrates a significant technology, but that its performance is inadequate for realistic evaluation of driver-vehicle interaction in accident threatening situations.

ENABLING TECHNOLOGIES

Recent breakthroughs in mechanical system dynamics and parallel computation developed in the Center for Simulation and Design Optimization at The University of Iowa, summarized in Fig. 3, have established the foundation for revolutionary new capabilities in vehicle driving simulation.

A high fidelity advanced driving simulator must be able to simulate broad classes of vehicles, in order to evaluate driver-vehicle performance in a variety of traffic and environmental conditions. Classes of vehicles to be considered include:

(1) Cars and Light Trucks
(2) Heavy Duty Trucks and Truck Combinations
(3) Busses
(4) Agricultural and Construction Vehicles
(5) Recreational Vehicles

Characteristics of vehicles that significantly influence their effectiveness and the safety of the driver-vehicle combination include:

ENABLING TECHNOLOGIES FROM *NSF-ARMY-NASA CENTER FOR* SIMULATION AND DESIGN OPTIMIZATION

- Recursive Dynamics (factor of 10 speed-up)
- Parallel Computing Algorithms (factor of 10 speed-up)
- Use of Faster Microprocessors (factor of 10 speed-up)
- Combined, we have broken the "real-time barrier"

Figure 3. Enabling Technologies

(1) Vehicle Steering Response and Driver Reaction
(2) Vehicle Rollover Threshold and Driver Feedback for Different Loadings
(3) Ride Comfort and Fatigue
(4) Vehicle-Driver Response to Anti-Skid Brake Systems
(5) Tractor-Trailer Dolly Converter Stability
(6) Vehicle-Pavement Interaction
(7) Vehicle-Driver Response During Component Failure

In order to determine how these characteristics influence the advanced driving simulator configuration and operational requirements, vehicle dynamic response characteristics and ride and handling stability are being analyzed as part of our study.

Vehicle performance is addressed in the study by considering two main factors:

(1) Handling; i.e., controllability in critical situations, insensitivity to driver mistakes, traction, and directional and braking stability.

(2) Ride quality; i.e., the ability of the suspension to absorb long and short irregularities in the road surface and to reduce pitching, rolling, and yawing movement to a minimum.

Design parameters that define vehicle performance characteristics that must be represented in vehicle simulation have been defined, ranging from the wheelbase and the height of the center of gravity to complicated tire characteristics and suspension compliances. Vehicle handling and ride quality, which are complex functions of design parameters, have been analyzed in the study to define performance requirements on the driving simulator to assure realism of driver-vehicle interactions. Some of the major vehicle subsystems whose design parameters must be accounted for, in order to influence safety and performance, include the chassis, suspension, tires, steering system, and brake system.

Vehicle response parameters that influence driving simulator design include static and dynamic response characteristics of the vehicle; e.g., steering sensitivity, yaw response, and understeer-oversteer characteristics, independent of the characteristics of the driver. Provision is made in the conceptual design so that they may be determined by proving ground tests or from detailed engineering analysis.

One of the major applications of a high fidelity driving simulator is to identify the relationship between task performance of a vehicle-driver combination and details of the vehicle design. Use of an advanced driving simulator makes it possible to determine the performance and safety related characteristics of a vehicle, even in the design stage. In order to relate response parameters and task performance, for given design parameters, care has been taken in the study to select appropriate test conditions for each evaluation purpose envisioned.

The generic hazards defined in Table 1 are being used to define pre-crash scenarios that must be supported for human factors research with the advanced driving simulator.

Advancements in dynamic simulation and parallel computers offer approximately a factor of 1000 increase in the speed, hence realism, of vehicle dynamic simulation over that available in 1985 when the Daimler-Benz Simulator came on line. They represent an opportunity for revolutionary advances in the realism of a vehicle driving simulator, particularly for vehicles such as multi-chassis heavy trucks. Transfer of graphics and motion base technologies from the field of aircraft flight simulators, optimized for ground vehicles, will support the remaining needs of an advanced driving simulator.

A NATIONAL ADVANCED DRIVING SIMULATOR

An artist's concept of the advanced driving simulator that is envisioned as an outcome of the study is shown in Fig. 4. The physical components of the driving simulator, which will be housed in an approximately fifty foot high experimental bay, with multiple adjacent experiment staging areas, consists of a motion platform and a high resolution graphics display dome.

The motion platform supports the cab of a prototype vehicle in which the driver sits and views the scene that is projected on the dome. Motion felt by the driver is created by the actuator system shown in Fig. 4 and by high frequency vibrators on the motion platform. These actuators and vibrators will support up to one hundred cycle per second high resolution motion that the driver would feel in operating the actual vehicle.

Horizontal movement will be permitted throughout a 30 x 90 foot rectangle, with up to 15 ft/sec velocity and 1.0 g acceleration. This contrasts with horizontal movement of the Daimler-Benz driving simulator within a circle of only 10 foot diameter. Vertical movement is 4 feet, with up to 2.5g acceleration. Roll and pitch of up to 40° elevation

Table 1. Generic Hazard Event Definitions and Related Issues

CATEGORY	CIRCUMSTANCES	DRIVER BEHAVIOR ISSUES	IMPORTANT CUES	VEHICLE SUBSYSTEM ISSUES	DRIVER/VEHICLE SYSTEM PERFORMANCE ISSUES
1. Unexpected Intrusions: Situations requiring visual detection and significance pre-crash avoidance maneuvering	• Obstacle suddenly and unexpectedly appears on a collision course	• Detection time • Probability of response alternatives: Brake and/or steer, freeze (do nothing) • Transient response characteristics	• Visual • Motion • Control feel • Auditory	• Steering • Brakes • Tires • Suspension	• Detection time • Control stability • Continual probabilities of success, control loss and/or collision give driver response
2. Unexpected or Mis-judged Environmental Situation: Focus on visibility/perceptual problems and post encounter maneuvering	• Excessive speed for road geometry • Change in road adhesion • Slow moving vehicles • Gap acceptance	• Detection • Recognition • Perceptual accuracy • Decision • Maneuver responses given above	• Visual/perceptual • Motion • Control feel	• Direct and indirect visibility • Warning systems (e.g., radar braking)	• Probability of detection • Recognition time
3. Sudden Change in Vehicle Response Characteristics: Situations where vehicle response characteristics change suddenly and unexpectedly	• Component failures (blow-out, power steering failure) • Road surface anomalies (e.g., pavement drop off)	• Detection of change • Recovery and adaptation to new response characteristics	• Motion • Control feel	• Steering • Brakes • Tires • Suspension	• Detection time • Adaptation time • Probability of control loss • Control stability
4. Predisposing Variations in Vehicle Response Characteristics: Focus on driver adaptability, particularly under emergency situations	• Loading • Tire pressure • Trailer towing • Unfamiliar vehicle	• Ability to compensate particular under emergency conditions	• Motion • Control feel	• Steering • Brakes • Tires • Suspension	• Control stability

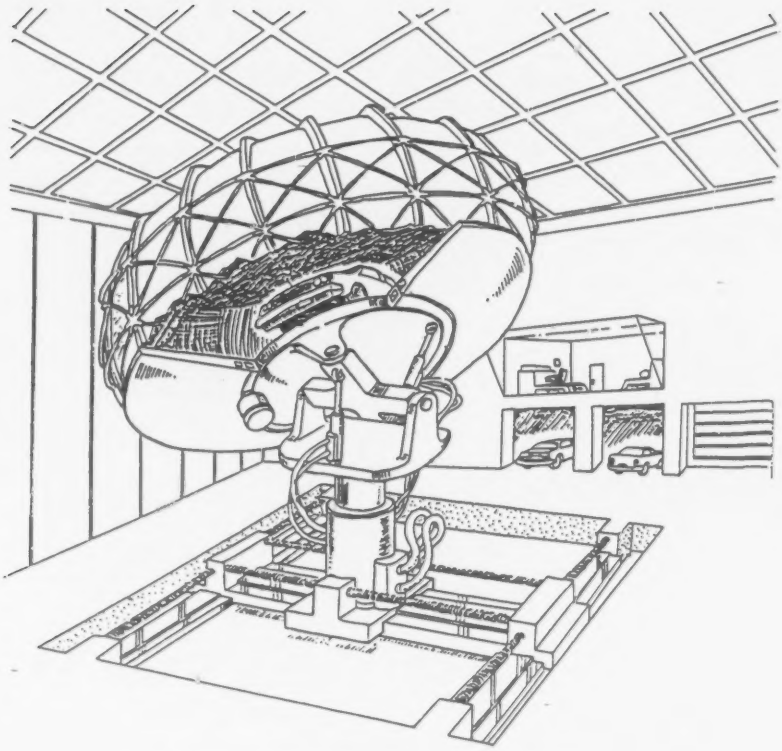

Figure 4. Vehicle Driving Simulator Concept

and depression will be permitted, with angular rates of 60°/sec and angular accelerations of 500°/sec^2. Finally a yaw ring on the platform will permit continuous yaw, with angular rates of 120°/sec and angular accelerations of 1000°/sec^2. Motion will be generated by electro-hydraulic motors and actuators, requiring a total capacity of 2,550Hp. This motion envelope and the associated motion platform design were derived from vehicle dynamics associated with specific scenarios from the classes outlined in Table 1.

Graphics computers and display devices will create high resolution scenes that are viewed by the driver. Eight graphics processors and projectors will generate and display images with at least 1,040,000 pixels for each 39° x 39° segment of the field of view. Texturing will be used to enhance image realism and dynamic acuity. An 85 Hz display rate will be achieved, with a pipeline delay of no more than 0.047 sec. Feed forward control from computer dynamic predictions will be used to reduce system transport delay to nearly zero. Motion, visual, and audio systems will be synchronized to achieve the highest fidelity vehicle driving simulator designed to date.

The driver operates the actual steering mechanism, accelerator pedal, brake pedal, and other operator interfaces in the vehicle. Sensors transmit the driver's actions to a high speed parallel computer, to create predictions of the resulting motion of the vehicle on the roadway. These predictions are then transmitted to the motion base, to control motion that is felt by the driver, and to the graphics computer and audio equipment to generate and display high resolution imagery and sound.

A parallel computer with approximately 64 processors will execute recursive dynamics software, to achieve less than 0.004 sec time step numerical integration of fully coupled equations of vehicle motion. Wheel rotation, weakly coupled high frequency vibration, and control state equations will be integrated at an approximately 0.001 sec time step. Essential nonlinear kinematic and dynamic effects will be included in the dynamics models, to realize the highest degree of vehicle dynamics fidelity ever achieved in a driving simulator. The software that supports dynamic computer simulation will be modular, permitting expansion of subsystem and system models to broad classes of vehicles.

Multiple staging areas will be provided in the driving simulator facility, to permit experiments to be prepared and dismantled, while another experiment is under way. Quick change experiment and instrumentation pallets will be used to permit switching from one experiment to another, within one or two hours in most cases.

SUMMARY

In summary, technologies are in hand to support a National Advanced Driving Simulator that will for the first time support controlled basic and applied human factors and vehicle design trade-off studies in simulated hazardous, even life threatening situations where no other form of experimentation is possible.

Mr. VALENTINE. Thank you.

Dr. Campbell is next on my list, a special welcome to you, sir, glad to have you here.

Mr. CAMPBELL. Thank you, it's nice to be here, sir. I can report to you that the ducks were in the air in North Carolina.

Mr. VALENTINE. Thank you, sir.

Mr. CAMPBELL. Since you've been on duty in this far outpost.

I would like to submit the full text that Dr. Hauser and I put together, but I think it's save some time, if it's all right with you, if I don't read it because a good many of the points that we have made in there have been touched upon and if it's okay with you, I'll just emphasize two or three points.

Mr. VALENTINE. Certainly.

Mr. CAMPBELL. I'm pleased to be able to be here to say that—to add my voice to the idea that we need in this country a renaissance in human factors research as it applies to motor vehicle crashes. For that last 25 years, we've been almost at a standstill in that regard.

And I don't say that particularly critically; I say it because it was—we had a very important period of catching up to do in this country and so, for the last 25 years, the greatest thrust of the research has been in the area of crashworthiness, making the vehicles more tolerant of a crash, making the roadway—the roadside features more tolerant of crashes.

But in that time, because of the limited resources, the other side of the question has been at a substantial standstill. In a way, it's a pity that these national choices had to be made, but with the amount of limited resources, there just wasn't enough and isn't enough research and development funds available through the funding agencies to support much of both of that sort of thing.

But I think we do need that now, in part because of the success we've enjoyed in the previous research. A lot of things that are now in place, or soon will be, the issue of occupant restraint, a lot of the initial wave of crashworthiness standards, a great transformation has taken place in terms of the crashworthiness of roadside features and we need to be looking ahead, in my opinion, to the next 10 or 20 years in terms of where we might go in terms of the next research phase in this country and I do believe the human factors.

Part of that is very much the tie-in. We've talked about automatic vehicles and the automatic guidance and so forth. There's a good deal of human factors research. I think of a couple of scenarios, for example. Suppose we have a dedicated lane for trucks and we have automatic guideways and so forth, and we've reduced very much the task loading of these truck drivers. They get on at Cleveland and it'll take them to Akron or somewhere automatically. And so they go to sleep because they don't have anything to do.

Now, I don't know whether we would be ahead of the game in a situation like that, but that's one of the—one of the questions that needs to be researched. How do we maintain the level of alertness or the level of arousal of drivers when they're in a situation where some of these functions have been taken away from them?

The other side of the coin, almost at the opposite extreme, is the research that is needed on the question of driver overload. If we begin to supply him with all this additional information, what is the best rate by which this information might be supplied to him? What is the point at which information overload gets to be a factor?

I'm reminded of talking to one of the combat pilots in the time of Vietnam and this is very much just an anecdotal comment and has no research basis, but he was talking about when he started really getting serious, getting into combat, the first thing he wanted to do was to start to turn off some of these information systems and concentrate on the single-minded task. His point—this one man's assessment being that he did at times suffer from information overload at the very most critical point.

Above all, I think if we are going to think in terms of a human factors research program that will and should take place over the next 10 or 20 years, we certainly need a comprehensive plan for what that program ought to be. We need to deal with a number of things. I'll stress, as others already have done, the question of the aging population. So many of the standards we've developed for visibility and signs and so forth on our vehicles have been developed using primarily young people as subjects. Now we have, for the first time in our history, this question of the aging population.

Then, as we get into this human factors research, I certainly think it would be appropriate to consider the kind of research tools we need to execute such a program of research on a national basis and one of them might be a simulator. There's certainly been a lot of technological breakthroughs that—since the last major simulator study was done by the Department of Transportation 20 years ago.

I think we need a restudy. Maybe that's what's going on right now. Because we need to look also, I might say—I hate to be the one person that might suggest any downside to simulators. We haven't had an altogether successful story in the past. Some people have characterized these simulator or high fidelity as a research tool looking for a problem to solve. We need to make sure we have defined a series of problems that would be worthy of keeping such a facility fully occupied.

I think that can be done, but I recall that the one previous attempt to build what was then a state-of-the-art simulator, the U.S. Public Health Service, about 25 years ago—eventually they just dismantled it and put it in in the warehouse because, at that time, it wasn't being fully utilized. I think we can avoid that, but I think that's an important part.

I will stop with that, Mr. Chairman, and to say that I do most desperately—most urgently endorse the idea of extended human factors research so that it will tie into the intelligent vehicle highway systems in the future.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Campbell follows:]

Issues Concerning Advanced, Intelligent Transportation System (A.I.T.S.) and Human Factors Research in The United States

Prepared for the Subcommittee on Transportation, Aviation and Materials
United States Congress
Honorable Tim Valentine, Chairman

by

Edwin W. Hauser, P.E., Ph.D., Director
Institute for Transportation Research and Education
The University of North Carolina

and

B. J. Campbell, Ph.D., Director
Highway Safety Research Center
The University of North Carolina

We are delighted to present these remarks concerning the need for advanced technology and human factors research that has the potential to reduce traffic congestion and automobile accidents.

I. Advanced Technology

A list of the various components that are in various stages of development for a comprehensive, integrated surface transportation system include the following. All are in need of further research.

(1) Advanced Driver Information Systems, such as the trip planning information systems that are being offered on some new car models;

(2) Automated Vehicle Control Systems, such as anti-collision systems;

(3) Advanced Traffic Management Systems, such as Land Mobile Satellite Services; and

(4) Freight and Fleet Control/Operation Systems.

What is needed to tie these somewhat independently-developed technologies together is a concept we have called an advanced, integrated transportation system (A.I.T.S.), a surface transportation system that includes the

intelligent vehicle-highway system (I.V.H.S.) that is the topic of research and discussion in various forums at this time. A.I.T.S. as a concept grew out of a meeting of the Southeastern Transportation Roundtable, which convened in Nashville, Tennessee, in March, 1989. A.I.T.S. adds to the I.V.H.S. concept such systems as downtown people movers that must become a more common high-density element of our urban transport systems in the future. Specific issues that have been raised for I.V.H.S. are nevertheless similar for A.I.T.S.

There is definitely a need in our opinion for a national research and development, and Technology Transfer program that would form the basis for implementating A.I.T.S. technology by the year 2000. There are several factors of national importance that relate to the need for moving forward at this time with an advanced, integrated transportation system. One of these factors is that global economic competitiveness relies heavily on the U. S. improving our overall tranportation systems. Another is the replacement of our aging infrastructure, of which more than 60 percent directly involves transportation facilities.

The overall goal should be no different than the goal for our current transportation system: to manage mobility in the safest, most efficient and cost-effective manner possible. If there is a change in the overall goal of A.I.T.S., it should be on emphasis. The emphasis should be on improving mobility of people and goods, not simply moving vehicles.

There is general consensus among the research community that advanced systems such as the four components of an advanced system we mentioned above will not require major new basic research initiatives, but on adapting and testing state-of-the-art communications, microprocessors, and command and control software to the special needs of surface transportation systems. Beyond these four technical components, the need exists for research dealing with policy and planning due to shifting responsibilities, economic

development implications, and the impacts on international trade.

One final comment on an estimated size for the research and development, demonstration, and technology transfer program that may be appropriate for a program such as A.I.T.S.. A European program developed by the private sector, "PROMETHEUS", is directed toward an I.V.H.S. type program of traffic management and control. PROMETHEUS, is projected as a 7-year, $800 million program of R & D.

No estimates for a nationwide research program such as the comprehensive A.I.T.S. program described herein have been made. However, it has been estimated that the size of the automotive electronics market will grow to $28 billion annually by the year 2000. Perhaps a reasonable effort to consider for the A.I.T.S. R & D, demonstration, and technology transfer effort should be projected as one percent of this figure, or about $280 million annually.

There are reasons to believe that the cost for an advanced, integrated transportation system would be a catalyst for other technology and economic growth in the United States. The identified need and the proposed program suggest a way that the basic needs of safe and efficient mobility can be achieved in this country in the early part of the next century.

II. Human Factors

The recommendations we are offering for your consideration this morning are rather simple. We badly need restoration of a national program of research on human factors in motor vehicle crashes.

During the past twenty-five years, important research in this topic has been deferred in the interest of other research that was higher on the agenda. In particular, the last 25 years has been marked by emphasis on crash worthiness research conducted to make vehicles more survivable in the event of a crash and to make roadside features safer if cars crash into them.

I have supported that research priority during the last 25 years because the nation was faced with an urgent need to "catch up" after having largely ignored the vital topic of crash injury control to that point in the motoring age. Now, however, important gains have been made in this area and our nation enjoys the lowest motor vehicle death rate in our history.

We now need a renaissance in human factors research precisely because some of the major gains in crash worthiness are now in place or will be in place in a few years (occupant restraint, for example). We face increasing problems of congestion, increasing numbers of road users, and of course, a significant population aging process is underway in the U.S. for the first time in our history. Still another factor urging the imortance of human factors research is the other topic of this committee's interest -- the prospects for greater use of computers and electronics for so-called "intelligent highway-vehicle systems."

Central to such a system is an understanding of the information processing capacities and decision capabilities of drivers in the traffic stream. Even though, in some respects, the "smart highway" is designed to remove the human factor from the "loop", the fact is that the "smart highway" may capitalize and profit from human factors research relating to the information needs of the driver, and the best manner for presenting information thereto.

First and foremost in this renaissance of human factors research is the need for a planned program of research. The research needs to be carried out over a period of ten to twenty years, covering a wide range of important topics; therefore, a comprehensive initial plannng process is needed to set the goals for such research.

We recently worked with a group of researchers under the auspices of the

Federal Highway Administration. We were planning a ten to twenty-year research program for consideration by that agency, and we stressed human factors research as one of the essentials.

The goals and procedures established by a planning process are the first step of the process, and only after those are clearly in mind should one think about the needed research measurement tools to support the program. I mention that because of the periodic interest (now renewed) in the desirability and the prospects for a single, large, high-fidelity driving simulator.

There has been considerable interest in driving simulators over the years, and various fixed-base simulators have been built, as well as on-the-road simulators in the form of instrumented vehicles. There has been some bad experience with these devices and also some good experience.

On the down side, some people have characterized the high-fidelity driving simulator as a very expensive research tool looking for a research problem to solve -- alluding to the fact that past simulators have sometimes been under-utilized once available.

The simulator built by the U. S. Public Health Service in the 1950's - 1960's was state-of-the-art at the time, but was later dismantled and put in a warehouse because that simulator was so little used.

It is certainly true that there have been some recent, significant technical innovations that have made a large, high-fidelity simulator more feasible in the past. The significant "plus" side factors include the development of computer graphics as a way of presenting the driver with a realistic visual display, and the availability of computers with enough "muscle" to make the calculations fast enough to update the visual scene that required several times per second to give it fidelity.

Also, the ability to utilize the six-degree-of-freedom motion platform developed for aircraft simulation is an important step forward. As the

committee doubtless knows, there is a "world class simulator" now being operated in Berlin by Daimler-Benz.

Whether it is now time for such a large scale simulator in the U.S. is, in our opinion, however, not so much a question of whether such a tool can be built, but whether a revitalized human factors research program presently requires such a tool.

There was a study twenty or twenty-five years ago on the need for, and the feasibility of, simulators. It seems to us an early planning task would be a 1990's version of such a study. Obviously, simulator technology has increased by orders of magnitude, and it will be interesting to determine whether the research needs for such a device have increased enough to make its construction and maintenance advisable.

Finally, there are one or two research tasks we would like to mention as being illustrative of human factors research we should undertake as a nation.

1. It might be advisable to resume and extend research of the sort done at Ohio State on the role of eye movements in the driving task. It is of interest to know what the eye is looking at any given time during the driving task. It would be of interest to know how the driver's visual scanning rate changes under different circumstances.

2. Another important area is the study of ways to sustain a high level of alertness or arousal of the driver during all phases of the driving task, particularly on long trips. This is not a new problem. It was known during World War II that sometimes sailors on watch, or operators monitoring radar scopes would, though awake, find that their level of arousal had dropped so low that sometimes when a target would appear they would literally not notice it even though their eyes were open. Through techniques of behavior modification, it seems likely that in-car systems can be developed to sustain

the required level of alertness.

3. As a final example, there is the issue of the aging population. One area would be research to examine the information processing rates, and the information requirements, of elderly drivers, and also the likely point of breakdown in their ability to process such information.

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EDUCATION:

B.A., M.A.	Texas Christian University	1951, 1953
Ph.D.	University of North Carolina	1960

HONORS:

1. Recipient, 1989, R. Crum Award for Research, U.S. Transportation Research Board.
2. Recipient, 1988, Volvo International Traffic Safety Award, Sweden (Research Prize).
3. Recipient, 1984, Volvo Public Safety Award.
4. Recipient, 1980, Public Service Award, National Highway Traffic Safety Administration.
5. Recipient, 1978, Distinguished Service Award, American Association for Automotive Medicine.
6. Recipient, 1976, Alvah Lauer Award from the Human Factors Society.
7. Recipient, 1972, Distinguished Service Award from the North Carolina Public Health Association.
8. Recipient, 1971, Metropolitan Research Award (Commendation), National Safety Council.
9. Recipient, 1960, Metropolitan Research Award, National Safety Council (Research Prize).

APPOINTMENTS:

1. Chairman, 1988-, Global Traffic Safety Trust, Melbourne, Australia
2. Member, 1987-, National Motor Vehicle Safety Research Advisory Committee. U. S. Department of Transportation.
3. Member, 1987-88, Committee to Identify Measures To Improve Safety of School Bus Transportation, National Research Council.
4. Member, 1987 -, Board of Directors, Association for the Advancement of Automotive Medicine.
5. Chairman, 1983-1986, National Driver Register Advisory Committee, U.S. Department of Transportation.
6. Chairman, 1983-1984, National Research Council Committee on Study of CB Radios on Buses.
7. Chairman, 1976-1977, Panel on Automotive Assessment into the 21st Century, U.S. Congress Office of Technology Assessment.
8. Chairman, 1975-1976, National Motor Vehicle Safety Advisory Council, U. S. Department of Transportation.
9. Chairman, 1964-1968, Committee on Accident Statistics, National Safety Council.

PREVIOUS POSITIONS:

1) Head, Accident Research Branch, Cornell Aeronautical Laboratory, 1962-1966; 2) Assistant Director, Automotive Crash Injury Research, Cornell University, 1960-1962; 3) Assistant Director, Institute of Government, UNC, 1958-1959

EDWIN WILBUR HAUSER
Director
The UNC Institute for Transportation Research and Education

EDUCATION:

B.S.C.E.	Civil Engineering, North Carolina State University, 1963
M.R.P.	City and Regional Planning, University of North Carolina, 1965
M.S.	Transportation Engineering, North Carolina State University, 1966
ASF Fellow	Transportation Systems Analysis, Northwestern University, 1968-69
Ph.D.	Transportation Planning, North Carolina State University, 1975

EMPLOYMENT:

1984 to date	Director, The Institute for Transportation Research and Education, The University of North Carolina-General Administration
1979 to 1984	Deputy Director, Institute for Transportation Research and Education
1980 to date	Adjunct Associate Professor of Civil Engineering, NC State University
1969 to 1979	Senior Transportation Systems Planner, Research Triangle Institute
1973 to 1979	Visiting Lecturer, Department of Civil Engineering, Duke University
1967 to 1968	Captain, Corps of Engineers, U.S. Army, Assistant Operations Officer, 815th Engineer Battalion (Construction), Vietnam
1966 to 1967	Lieutenant, Corps of Engineers, U.S. Army, Post Engineer, Charleston Army Depot, South Carolina
1966	Transportation Planner, Harland Bartholomew and Associates, Raleigh, NC
1964	Community Planner, N.C. Dept. of Conservation and Development, Salisbury, NC

PUBLICATIONS:

Authored and co-author of over 90 reports and technical memorandums in the areas of transportation energy use, environmental analysis, highway safety, transportation systems management and planning, and regional development. Author or co-author of over 40 papers prepared for publication or presentation.

REGISTRATION:

Registered Professional Engineer in North Carolina, #12314.

PROFESSIONAL SOCIETIES, HONORS, AND AWARDS:

Transportation Research Board
Institute of Transportation Engineers, North Carolina Division
American Road and Transportation Builders Association
American Public Works Association
Automotive Safety Foundation Fellowship
Theta Tau Engineering Fraternity
Elected to Tau Beta Pi, Chi Epsilon, and Phi Eta Sigma
Listed in Notable Americans of the Bicentennial Era
Council of University Transportation Centers, President (1985-86)
North Carolina Public Transportation Association

AREAS OF SPECIALIZATION:

Transportation engineering and planning, transportation energy use and conservation, research in highway safety, transportation systems management, organizational development.

Issues Concerning Advanced, Integrated Transportation System (AITS) Development in The United States

Prepared for the Subcommittee on Transportation, Aviation and Materials
United States Congress
Honorable Tim Valentine, Chairman

by

Edwin W. Hauser, P.E., Ph.D., Director
Institute for Transportation Research and Education
The University of North Carolina

This paper has been prepared in response to a request for an impartial opinion on the need for advanced technology and human factors research that has the potential to reduce traffic congestion and automobile accidents. The various issues can be divided into two distinct categories, and the area of human factors research needs is being addressed in a companion paper by Dr. B. J. Campbell, Director of the UNC Highway Safety Research Center.

Before addressing the current scenario concerning issues affecting advanced transport system technology, it would be useful to identify a number of relevant caveats or assumptions concerning the state of the nation and world for the forseeable future. These caveats are:

* The world population will continue to grow, and will reach 6 billion in the year 2000. The population of the U.S. will continue its more modest current growth rate.
* Our urban regions will continue to grow more rapidly, even as the nation's population becomes more evenly distributed. U. S. society will continue to become increasingly dependent on personal transport as the principal means of travel.
* Highway traffic volumes will double to about 3.8 trillion vehicle miles by the year 2020.
* Fatalities on America's highways will increase to about 80,000 per year by the year 2000, if the current fatality rate continues.

* The real price of transportation fuels will increase slowly until substitution has occurred. Fuels that are cheaper and emit less emisions will be developed by the year 2020.
* No new oil crisis is assumed. If such a scenario develops, a more dramatic national commitment to developing synthetic automotive fuels will occur, speeding up the timetable hypothesized above.
* The long-term trend of decreasing costs for computer and communication equipment will continue to make real-time driver information and vehicle control systems feasible for the general public. (This will be the major theme of this paper.)
* The neglect of our railway infrastructure is assumed to be irrevocable due to high investment costs. As a result, the demand for roadway freight transport will continue its high growth of the last two decades. This will place a high value on the development of freight and fleet control and operational systems.

An overall conceptual framework in which the three sub-systems of the surface transportation system interacts is shown below:

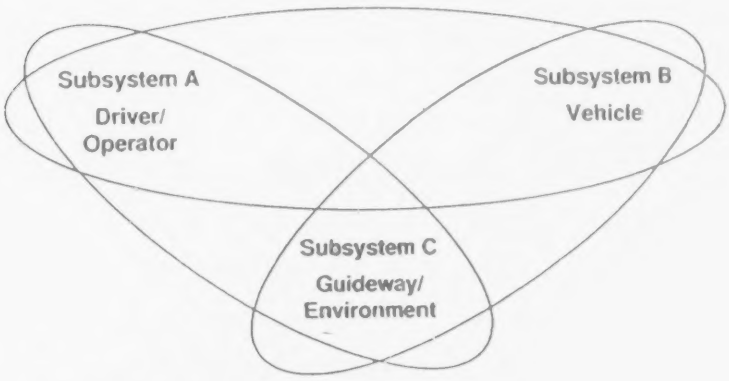

Figure 1. Interaction of subsystems in the Transportation Environment

This paper is built on various concepts that have been studied and debated in the following programs, among others:

(1) a 1986-87 project called "Automobile Road Information System Evolution" (ARISE), conducted by an international panel and coordinated by the International Institute for Applied Systems Analysis, Laxenburg, Austria;

(2) a multi-university/government/industry committee effort called "Mobility 2000", whose efforts are directed toward evaluating all existing advanced vehicle/highway technology, share their findings, and work jointly to develop a national highway transportation plan for the future;

(3) a "Discussion Paper on Intelligent Vehicle-Highway Systems", issued by the Office of the Secretary of Transportation, USDOT, in response to the Conference Report on the FY 1989 USDOT Appropriations Act, May, 1989; and

(4) a discussion paper called "Mobility 21: Managing Mobility in a High Growth Region in the 21st Century", which resulted from the work of the Southeastern Transportation Roundtable, an industry/government/university group convened by the Southeastern Consortium of University Transportation Centers (SECUTC), March, 1989.

The institutional environment for developing an advanced, integrated transport system can be depicted as follows:

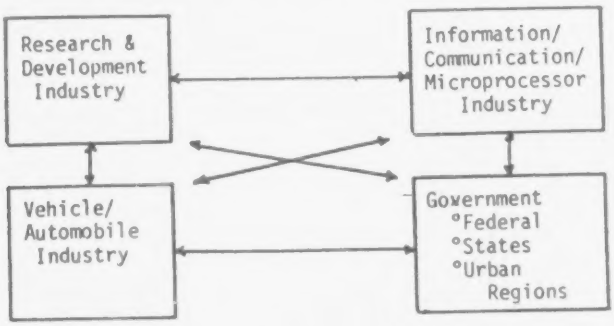

Figure 2. Environment for Developing an Advanced, Integrated Transportation System

Although the three subsystems depicted in Figure 1 and the institutional entities identified in Figure 2 must all be considered as part of the overall surface transportation system, the remainder of this paper will focus on the contribution of the research community (universities, in particular) and the various levels of government in developing an advanced, integrated transport system (A.I.T.S.). Following on the caveats above, it is a reasonable assumption that the auto/vehicle industry and the information/communication industry will react to market forces and provide the public with the components (sensors, computers, servos) that the market is willing to buy. Without going in depth with a description of the various components that are in various stages of development, a rather comprehensive (but not all-inclusive) list of technologies currently available or in some stage of development includes:

(1) Advanced Driver Information Systems

* On-board, general purpose computer
* Driver identification technology
* Head-up/head-down display instruments
* In-vehicle voice recognition system
* Integrated data base system
* Geographic information systems
* Pre-trip information system
* "Driver alert" systems

(2) Automated Vehicle Control Systems

* Vehicle sensor technology
* Vehicle-to-vehicle data link
* Automatic chauffering technology
* Road usage pricing and debiting systems
* Anti-collision systems
* People moving systems (including PRT)

etc.

(3) Advanced Traffic Management Systems

* Roadside sensor technology
* Vehicle-to-roadside data link
* Traffic flow management and monitoring systems
* Integrated traffic signal systems

* Anti-pollution control technology
* Guideway technology
* Geographic positioning systems, e.g.:
  - Radio Determination Satellite Service (RDSS)
  - Land Mobile Satellite Service (LMSS)
  - Long Range Navigation System (LORAN, LORAN-C)
  - Dead reckoning systems

etc.

(4) Freight and Fleet Control/Operation Systems

* Fleet management systems
* Vehicle delivery invoicing and re-ordering systems
* Load off/load on redistribution systems
* Weigh-in-motion systems
* Vehicle tracking systems

etc.

Most, if not all, of the above systems and components are in need of further research and develoment, market testing, or demonstration if we are to develop a surface transportation system that is significantly safer than the present one. With the advent of automated landing systems for aircraft, a factor of 10 in safety improvement over manual landing was one of the design criteria. It is time for just such a dramatic improvement in safety on our highways, in order to avoid the 80,000 annual fatalities currently projected.

The proposal that is outlined in this paper is for an advanced, integrated transportation system (A.I.T.S.), a surface transportation system that includes the intelligent vehicle-highway system (.I.V.H.S) that is the topic of research and discussion in the "Mobility 2000" documentation. A.I.T.S. as a concept grew out of the meeting of the Southeastern Transportation Round-table, which convened in Nashville, Tennessee, in March, 1989. A.I.T.S. adds to the I.V.H.S. concept such systems as downtown people movers that must become a more common high-density element of our urban transport systems in the future. Specific issues that should be raised for I.V.H.S. are nevertheless similar for A.I.T.S., specifically:*

*Adapted from the I.V.H.S. Discussion Paper, USDOT.

(1) Is there a need for a national A.I.T.S. research program?

(2) What should be its goals?

(3) What is an appropriate initial research agenda?

(4) What are appropriate roles and responsiblities of various levels of government, the private sector, and universities/research institutes?

(5) What is the most appropriate organizational structure to manage A.I.T.S.?

(6) What funding levels, sources, and time-table is appropriate to achieving the goals of a national A.I.T.S. R&D program?

The first four questions will be addressed in this paper. The last two questions need further discussion and information, and Congressional response to the first four, before addressing the latter two, except for a very general suggestion of a level of funding for such a program.

First, there is definitely a need for a national research, development, and demonstration program that would form the basis for implementating A.I.T.S. technology by the year 2020. It is generally considered reasonable for a 40 to 50 year development period from conceptual idea to full acceptance in the market place. If the "seeds" of the A.I.T.S. technology were planted in the 1960's, then full implementation in the 2020's would be a "normal" development time. Of course, "fast track" R and D such as the original space program sometimes compress this normal development time.

There are several factors of national importance that relate to the need for moving forward at this time with an advanced, integrated transportation system. One of these factors is simply the fact that our nation is "half-way there" on the time line, and the technology is available but at present simply lacks a focus for developing it into a coordinated program. Next, global

economic competitiveness relies heavily on the U. S. improving our overall tranportation systems. Our surface transportation system must keep pace with improvements in overall air and water transport systems, which are also needed. A final factor mentioned here is that of our aging infrastructure, of which more than 60 percent directly involves transportation facilities, and much of that surface transportation. If our nation is going to have to replace much of our capital facilities during the next two to four decades, then why not replace it with the latest technological innovations that we can afford as a nation? Stated another way, can the world's most advanced nation afford to replace its infrastructure with anything less than the latest technology. The initial conceptual stage for many of these technologies, as listed above, is already "on the drawing board". The question is whether we have the national will to bring these technologies to fruition.

The second major question to be addressed: What should be the principal goals of implementing A.I.T.S. on a national scale? The overall goal should be no different than the goal for any heretofore developed transportation system: to manage mobility in the safest, most efficient and cost-effective manner possible. If there is a change in the overall goal of A.I.T.S., it should be on emphasis. The emphasis should be on the two sub-goals of improved mobility of people and goods. People - since efficiency in moving people requires that attention be focused on their needs rather than vehicles if we are to avoid further gridlock. And goods - since efficiency in moving goods is critically important in maintaining a competitive advantage for economic development in the world marketplace.

Third, what is an appropriate initial research agenda? There is general consensus among the research community that advanced systems such as A.I.T.S will not require major new basic research initiatives. Rather, the

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emphasis should be generally on adapting and testing state-of-the-art communications, microprocessors, and command and control software to the special needs of surface transportation systems. Overall program direction and a sample of specific research and development needs in each of the four major technology areas have recently been identified in the USDOT "Discussion Paper." The four technology areas - advanced driver information, automated vehicle control, advanced traffic management, and freight and fleet control and operations - are considered by some to be equally important in the development of a balanced transportation system. It is the view of others, however, that perhaps a higher priority should be placed on the latter program area, specifically truck safety. With the trend being for trucks to continue to be larger, and the average automobile size continuing to be smaller, a higher potential exists for conflicts and crashes involving trucks and automobiles.

Beyond these four technical areas, the need exists for research dealing with policy and planning due to shifting responsibilities, economic development implications, and the impacts on international trade. Four specific policy and planning areas are suggested:

(1) Policy research - to explore regulatory, institutional, and social issues that accompany technological developments of A.I.T.S.

(2) Long-term research - must receive considerable priority since it is largely ignored in most current transportation research programs.

(3) Geographic information - developing compatible state-of-the-art systems should be an immediate activity of major consequence inasmuch as the applications of GIS can be very broadly applied in national, statewide, regional, and urban transportation programs.

(4) Policy interaction - between transportation planning and land use development is urgently needed. Although the obvious connection between density of development and transportation systems is commonly understood, decision-makers at local levels need information and training in this area. This is a major "technology transfer" need that is widely recognized by local officials.

Fourth, concerning the respective roles of the various participants in the proposed A.I.T.S. research and development program: in a brief reference to Figure 2, above, the hypothesis is that in all likelihood the vehicle industry and the information/communication/microprocessor industry are collaborating on development of most of the subsystems required for the advanced driver information systems. The federal government must take a major role in development of the three remaining systems, however. In addition, a major national commitment at the federal, state, and local level needs to be placed on reducing congestion and pollution from mobile sources in our large urban areas. The health of our citizens is in desperate need of improvements in this area.

A comment is warranted about the appropriate role of universities, and particularly university transportation centers and institutes such as ours in North Carolina. Universities are in a position, given adequate resources, to effectively play a major role in developing and improving technologies that make up an advanced, integrated transportation system. Universities can exercise independent judgment in resolving technical issues. University researchers have accepted the challenge to stimulate new research activities with creative ideas and entrepreneural advances. Universities are also beginning to effectively play an active role in brokering and participating in public/private partnerships for research and implementaton.

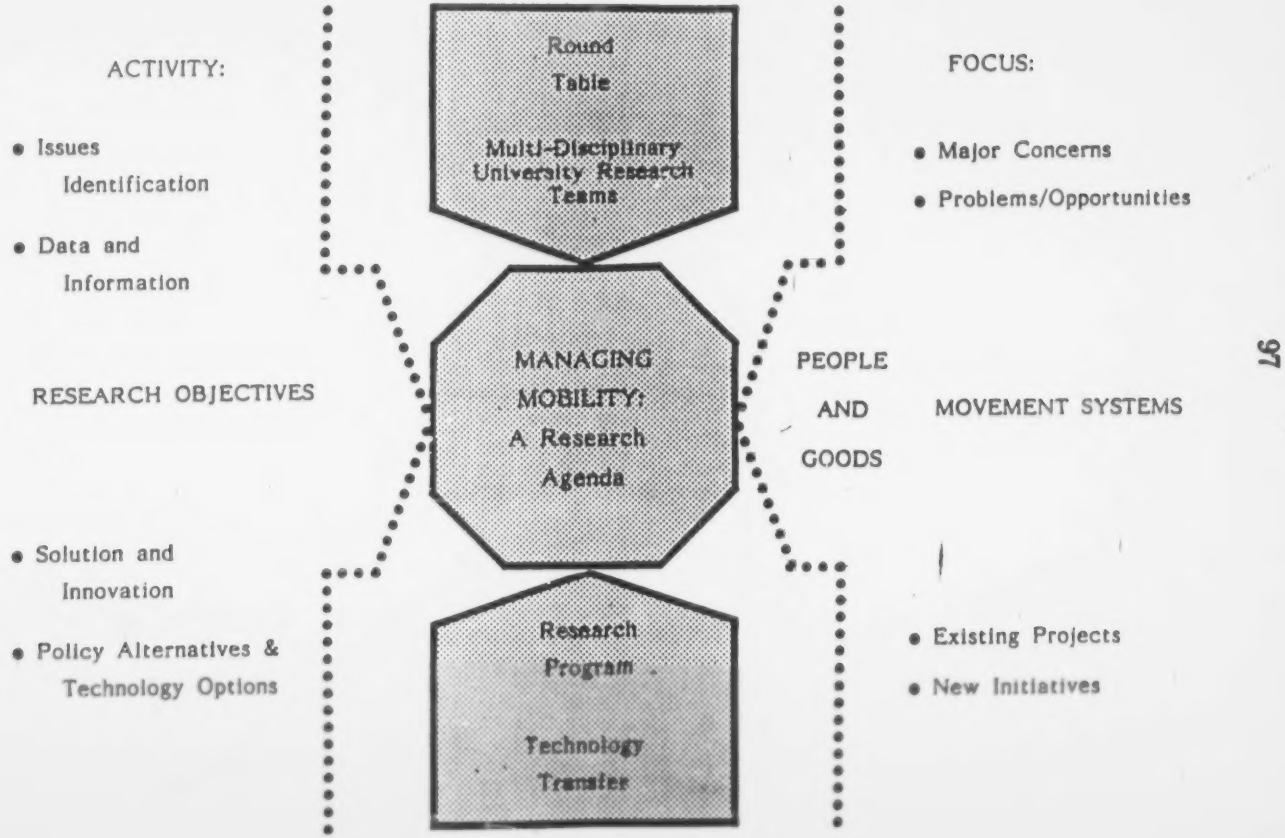
The USDOT, as authorized by the 1987 Surface Transportation and Uniform Relocation Assistance Act, has designated a university consortium in each of the 10 federal regions as a "USDOT University Transportation Center." The University of North Carolina system is the lead institution in Federal Region IV for purposes of this program. The list of lead institutions and consortium members in each region is shown in Appendix A. As mentioned above, the Region IV University Transportation Center is called the Southeastern Consortium of University Transportation Centers (SECUTC).

Working with the Southeastern Transportation Roundtable, a broad-based program of research and technology transfer has recently been developed by SECUTC. Figure 3 shows how SECUTC has begun to conceptualize a framework for the development of a regional research program. Several related proposals are keying from this conceptual framework and are under development by member institutions of SECUTC.

In Figure 3, the activities and outcomes involved are listed on the left side with the organizing focus shown on the right side. The research agenda will serve as a plan for the research program and technology transfer (training activities, etc.) to follow. The goal is for increased innovation and solutions that will provide useful policy alternatives and technology options. Each of the 10 regional centers have a "research theme" that guides their annual work program. Our theme for the Region IV center is "Mobility 21: Managing Mobility in a High Growth Region for the 21st Century". As another example, the Region VI center has a theme focusing on truck safety and transportation. In summary, universities have worked with the USDOT, AASHTO, the U. S. Congress, state DOT/SHA's, and other groups, to establish and maintain a capability of addressing major national research agendas such as the one needed for developing a nation-wide, advanced, integrated trans-

Figure 3

SECUTC FRAMEWORK FOR A REGIONAL POLICY AND RESEARCH PROGRAM



portation system.

One final comment on an estimated size for the research and development, demonstration, and technology transfer program that may be appropriate for a program such as A.I.T.S. A European program developed by the private sector, "PROMETHEUS", is directed toward an IVHS type program of traffic management and control. PROMETHEUS, for Program for European Traffic with Highest Efficiency and Unprecedented Safety, is projected as a 7-year, $800 million program of R & D.

No estimates for a nationwide research program such as the comprehensive A.I.T.S. program described herein have been made. However, it has been estimated that the size of the automotive electronics market will grow to $28 billion annually by the year 2000. Perhaps a reasonable effort to consider for the AITS R & D, demonstration, and technology transfer should be projected as one percent of this figure, or about $280 million annually. A five-year program would result in a total effort of $1.4 billion, which would compare favorably with the European program.

There are reasons to believe that the cost for an advanced, integrated transportation system would be a catalyst for other technology and economic growth in the United States. The identified need and the proposed program suggest a way that the basic needs of safe and efficient mobility can be achieved in this country in the next century. Such a program would be an opportunity for government, industry, universities, and the whole scientific community to cooperate efficiently for the common good.

APPENDIX A

U.S. DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION ADMINISTRATION

UNIVERSITY TRANSPORTATION CENTERS

Region I MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Center Director: Tom Humphrey (617) 253-4978

Consortium Schools:
Harvard University (MA)
University of Connecticut
University of Maine -
University of Massachusetts at Amhurst
University of New Hampshire
University of Rhode Island
University of Vermont

Region II CITY UNIVERSITY OF NEW YORK
Center Director: Milt Pikarsky (212) 690-8397

Consortium Schools:
Cornell University (NY)
New Jersey Institute of Technology
New York University
Polytechnic University (NY)
Princeton University (NJ)
Rensselaer Polytechnic University (NY)
Rutgers State University of New Jersey
State University of New York Albany
Stevens Institute of Technology (NJ)
University of Puerto Rico
University of Virgin Islands

Region III PENN STATE UNIVERSITY
Center Director: Jim Miller (814) 863-1909

Consortium Schools:
Morgan State (MD)
University of Pennsylvania
University of Virginia
Virginia Polytechnic Institute & State University
West Virginia University

Region IV UNIVERSITY OF NORTH CAROLINA CHAPEL HILL
Center Director: Edd Hauser (919) 549-0543

Consortium Schools:
Duke University (NC)
North Carolina A&T State University
North Carolina Central University
North Carolina State University, Raleigh
University of Florida, Gainesville
University of Kentucky, Lexington
University of North Carolina, Charlotte
University of North Florida, Jacksonville
University of Tennessee, Knoxville
Vanderbilt University (TN)

Region V — UNIVERSITY OF MICHIGAN (Ann Arbor)
Center Director: Tom Gillespie (313)764-6504

Consortium Schools:
Central State University (OH)
Michigan State University
Michigan Technological University
Northwestern University (IL)
Wayne State University (MI)

Region VI — TEXAS A&M UNIVERSITY
Center Director: Conrad Dudek (409) 845-1727

Consortium Schools:
Texas Southern University
University of Texas at Austin

Region VII — IOWA STATE UNIVERSITY
Center Director: Ben Allen (294-8104)

Consortium School:
University of Iowa

Region VIII — NORTH DAKOTA STATE UNIVERSITY
Center Director: Gene Griffin (701) 237-7767

Consortium Schools:
Colorado State University
University of Colorado at Denver
University of Minnesota
University of Wyoming
Utah State University

Region IX — UNIVERSITY OF CALIFORNIA (Berkeley)
Center Director: Mel Webber (415) 642-1820

Consortium Schools:
California State University, Long Beach
University of California, Davis
University of California, Irvine
University of California, Los Angeles

Region X — UNIVERSITY OF WASHINGTON
Center Director: Nancy Nihan (206) 543-8268
(206) 543-9639

Consortium Schools:
Oregon State University
Portland State University (OR)
University of Alaska at Fairbanks
University of Idaho
University of Portland (OR)
Washington State University

EDWIN WILBUR HAUSER
Director
Institute for Transportation Research and Education (ITRE)

EDUCATION:

B.S.C.E.	Civil Engineering, North Carolina State University, 1963
M.R.P.	City & Regional Planning, UNC-Chapel Hill, 1965
M.S.	Transportation Engineering, North Carolina State Univ., 1966
ASF Fellow	Transportation Systems Analysis, Northwestern Univ., 1968-69
Ph.D.	Transportation Planning, North Carolina State University, 1975

EMPLOYMENT

1984 to date	Director, ITRE, The University of North Carolina
1979 - 1984	Deputy Director, ITRE
1987 to date	Executive Director, Southeastern Consortium of University Transportation Centers
1980 to date	Adjunct Assoc. Professor of Civil Engineering, NC State Univ.
1969 - 1979	Senior Transp. Systems Planner, Research Triangle Institute
1973 - 1979	Visiting Lecturer, Dept. of Civil Engineering, Duke University
1967 - 1968	Captain, Corps of Engineers, US Army, Republic of Vietnam
1966 - 1968	1st Lieutenant, Corps of Engineers, Charleston Army Depot, SC
1966	Transportation Planner, Harland Bartholomew and Associates
1965	Research Assistant, Dept. of Civil Engr., NC State University
1964	Community Planner, NC Dept. of Conservation and Development

PUBLICATIONS:

Author and co-author of over 90 reports and technical memorandums in the areas of transportation management, transportation planning, highway safety, regional development, environmental analysis and energy use. Author or co-author of over 40 papers prepared for publication or presentation.

REGISTRATION:

Registered Professional Engineer in North Carolina, # 12314

PROFESSIONAL SOCIETIES, HONORS, AND AWARDS:

Transportation Research Board
American Road and Transportation Builders Association, President, Educational Division, 1989-90
American Public Works Association
Institute of Transportation Engineers, N.C. Section
Council of University Transportation Centers, President, 1985-86
North Carolina Public Tranportation Association
National Society of Professional Engineers
Professional Engineers of North Carolina, President, Educators Division, 1989
Theta Tau Engineering Fraternity
Elected to Tau Beta Pi, Chi Epsilon, and Phi Eta Sigma

AREAS OF SPECIALIZATION:

Transportation engineering and planning, management, economic analysis, safety

Mr. VALENTINE. Thank you, Mr.—thank you, Mr. Campbell.

Mr. Parsons.

Mr. PARSONS. Yes, sir, Mr. Chairman, and members of the subcommittee, it's my pleasure to be here before this committee again. I'm going to drastically reduce my prepared comments and conserve time and while I don't differ with my colleagues on this panel and those who preceded me on the human factors and need for simulator aspects, I'd like to address what—

Mr. VALENTINE. Excuse me just one minute, please, sir.

[Conferring.]

Mr. VALENTINE. The matter under consideration was the chairman of the full committee is meeting in the next room and the chairman has sent word he wanted as many members as possible to come and I just asked the lady to explain if he wanted us to close down this operation and go down to his meeting, so we'll—we'll find out shortly, but I don't think that will be the case.

I apologize for that interruption, sir.

Mr. PARSONS. I'd like to return to the bigger national issues of the emerging threat overseas of smart cars coming into this country and in bringing with them the smart technology for our highways and how that might affect our productivity, our balance of trade, and environment and safety on our urban highways.

I represent a bold new California initiative, as Director of the Program on Advanced Technology for the Highway, PATH, that is addressing the issue of basically Los Angeles and San Francisco, and you heard from Congressman Brown of the problems in Los Angeles and San Francisco is very close behind and we have almost every major urban area in the United States equal—some are equal to that, but others will be approaching that in the near future.

This topic of this hearing is just one of many transportation areas where we've lagged behind the Europeans and the Japanese. I'm not going to talk about the PROMETHEUS; you've heard about that, but there are good things starting to happen, I believe, and this—not the least of which is this hearing, and hopefully there will be others that will get this country back on the move. But we have to act and we need more central government and industrial support.

Efforts to date have been primarily initiated at the State level and these issues are too large for one, two, or four or five States.

PATH is under the general direction of Caltrans and it was addressing our urban congestion problem, which is starting to affect the viability of the economics of these two cities. In addition, that was noncompliance in air and our safety activities aren't what they should be, either.

The University of California is acting as the planning director and research manager for this program and have been very active in calling in other universities that have strong centralized transportation research capabilities, progressive state DOTs, automobile manufacturers, air suppliers, control and technology communications companies and the Federal Highway and NHTSA to form this informal partnership to address these issues.

Today, there are advanced highway/vehicle research activities at Texas A&M, University of Michigan and MIT, all supported by

their respective State DOTs. We frequently meet, as was indicated before, under the banner of Mobility 2000 and Lyle Saxton has been our most gracious informal moderator.

Even though California has always been a leader in advanced highways, its freeway designs and concepts were a major step in evolution of the current interstate we all enjoy today. In its recent commitment to bring smart corridors—to bring smart cars and smart streets together—is the first step towards our new highway systems of the future.

I want to dwell on the word "system," and this will answer some of the questions about the industry and government role. This is the only transportation system—and I've worked in three major ones, aviation, railroad and now this—there is no control system in this system. Once you marry the vehicle and the guideway, then it's necessary to provide a communication link that'll eventually be a control system, and you can't let this be designed by the industry alone. It can't be designed by the government alone. It requires a cooperative effort and we've chosen to try to have the universities involved as the go-between, these other forces, and evolve a sensible evolution of the next system of our highway, hopefully, that will be smarter and socially more forgiving than the one we have today. So the answer is that we need all three.

I'm just going to state one statement on what we're doing. My statement's over there. If anybody's interested, they can read it, but basically we're working in three areas. We're looking at a unique, noncontact electrified roadway propulsion system for use on buses, vans and cars on exclusive high-occupancy vehicle lanes in our cities. We're demonstrating the potential of electronic onboard navigation devices and companion in-street electronic means to provide route guidance to the driver as a means of reducing congestions. These may eventually move into a control system for a regional area.

And lastly, we're researching on how elements of vehicle automation may be introduced in an evolutionary manner to reduce major workloads of the drivers and put more throughput in the existing system.

We believe that safety and congestion are interrelated and until we get smooth flow of the traffic through some control mechanism, you're not going to adequately address either.

I'll wrap up by saying our congestion in California, as you heard Mr. Brown say, is very bad. We predict it will worsen significantly. Our congestion is growing at 15 percent per year. It has impacts on our economy, our environment, and the health and safety of our populace. The encouraging news is our State realizes it's in trouble. Three years ago, they realized they were in trouble. They initiated a major R&D program. We've had the privilege of leading that and we're trying to awaken the rest of the country to join us and solve this on a national level.

What we need is a strong Federal leadership. We need research support and we jointly have to get our U.S. industry involved in this because they have the wherewithal to design the products needed.

Thank you very much.

[The prepared statement of Mr. Parsons follows:]

TESTIMONY OF ROBERT E. PARSONS

Director, Program on Advanced Technology for the Highway
Institute of Transportation Studies
University of California
Berkeley, California

before the

Subcommittee on Transportation, Aviation and Materials

of the Committee on Science, Space and Technology

United States House of Representatives

June 7, 1989

Mr. Chairman and members of the Subcommittee.

I am Robert E. Parsons, Director of California's exciting new Program on Advanced Technology for the Highway. I work for the Institute of Transportation Studies at the University of California at Berkeley, California.

It is my pleasure to again appear before this committee. I am familiar with and respect the importance of your subcommittee. As a career research executive at the Department of Transportation (DOT), since it's creation in the late 60's until the early 1980's, I appeared before this committee as part of your oversight responsibility of ground transportation R&D.

Even after my departure from DOT, I had the pleasure to organize a field hearing for the committee in Las Vegas, in 1986, to address high speed rail technology (intercity ground transportation). At that time, Congressman George Brown was the chairman and I was in charge of the Super Speed Train Feasibility Study of the Las Vegas - Southern California corridor.

Today, I present a bold California initiative aimed at regaining the U.S. leadership in the automobile/highway field - an area where the European and Asian automobile companies have made great strides in the past and again pose a threat in the design of "smart" cars for the future. I might add that we feel, to some extent, that United States efforts are starting to gain a foothold. Many positive actions are underway, not the least of which is this hearing.

The first ten years of my career were spent in the aircraft industry, then I served as a Senior Executive with the Federal Aviation Agency as the Deputy Director of the Supersonic Transport Development Program, the Director of R&D Resources and Plans of the Office of the Secretary of Transportation,

the Associate Administrator for Research and Development of the Federal Railroad Administration and finally as the Director of the Office of Strategy and Evaluation in the Office of Assistant Secretary of Commerce for Productivity, Technology and Innovation. After twenty years of federal service, in 1981, I took an early retirement in frustration over lack of U.S. government support for what I believed to be essential U.S. transportation R&D programs that bear on our international competitiveness in this field. From my perspective our posture in this field has worsened ever since. Industry can't do it alone.

This committee knows well what has happened. Several administrations, in succession, have collectively gutted the central high risk R&D activities and, in the recent past, we have not adequately addressed the transportation infrastructure of our country. There is very little R&D in any commercial department. For example, my former offices of Research and Development in the Federal Railroad Administration have been abolished, There is no longer an Assistant Secretary for Technology at DOT or other major civilian agencies. There is no science advisor on the white house staff.

As a result, we have abandoned promising technologies, such as maglev, that foreign governments are trying to sell back to us on the argument that the U.S. can't afford to do the R&D. While I was at DOT, it was their policy to buy foreign products - since those setting policy argued that less expensive foreign transportation products helped us fight inflation. Anybody who has followed the results of those shortsighted policies realizes that, today, there are no U.S. producers left in some fields and that the foreign products are not so cheap anymore, once the American competition vanished.

The topic of this hearing represents another area where our country lags behind. European and Japanese interests are spending big money on research and demonstrations of advanced technology for the highway as we talk today.

But some good things are going on here, and perhaps as a result of this and other hearings, more appreciation of the issues and opportunities will result. We have an opportunity to regain America's leadership in highway transportation.

We fathered the automobile and the highway system that all enjoy, worldwide today. One may argue that our automobiles aren't as good as Japan's, Sweden's

or Germany's but nobody can deny that the U.S., vehicle/highway system has been the world's best - in terms of safety, productivity or any other measure. We invested in early highway research and built our interstate system and it has paid off handsomely.

The Program on Advanced Technology for the Highway (PATH), is under the general direction the California Department of Transportation, (CALTRANS) to address urban highway congestion, safety and pollution via selected application of high technology. Specifically, PATH is investigating a unique non-contact electrified roadway propulsion system for use on buses in exclusive high-occupancy-vehicle (HOV) lanes, demonstrating the potential of electronic on-board navigation devices to provide route guidance to drivers as a means of reducing congestion in certain urban corridors and lastly, researching how elements of vehicle automation may be introduced to provide a major increase in through put flow on our existing urban highway infrastructure while reducing accidents.

The University has also been active involving other leading universities, that have strong transportation research capability, state DOTs, automobile manufacturers and their suppliers, control and communication companies and the Federal Highway Administration R&D staff in a collective partnership to address these issues. There are now advanced highway/vehicle research activities at Texas A&M, University of Michigan and M.I.T., supported by the respective state DOT's. We meet frequently, on an informal basis, with Mr. Lyle Saxton of the FHWA acting as our informal monitor. This body is known as Mobility 2000 and it has created a new awareness and excitement in the research community.

California has been a leader in advanced highway systems. Its freeway concepts and designs were major steps in the evolution of the extensive inter-state system we all enjoy today. California's recent commitment to a "smart corridor" in Los Angeles will combine "smart roads" and "smart cars" - an important first step towards an advanced highway system.

Even with its reputation for being foremost in highway design and maintenance, Caltrans cannot keep up with the current and projected demand for highway services. During the last decade, urban travel has been increasing by 5-6% per year whereas highway capacity has increased at less than 1% per year. It is anticipated that, as trade expands between California and the rest of the

Pacific basin, our freight carrying capacity in the major urban areas will be severely taxed and this will come at a time of increasing demand by commuters and pleasure drivers to utilize the same road network.

In light of the increased traffic projections for California, it's important to smooth urban traffic flow and thus get at the heart of the congestion and accident issues and also improve air quality in the cities.

Californians understand that traffic conditions and congestion are major problems throughout the state and more communities are implementing anti-growth measures to combat these problems. However, such restrictive measures in turn will eventually impact the competitiveness of California as a producer of goods and services. Other world-trade-oriented countries have already seen these opportunities and are supporting aggressive, new R&D initiatives to directly solve the problems caused by urban automobile usage. These countries see large export markets in the United States for advanced highway electronics. The $800 million European "Prometheus" R&D program and similar large advanced highway R&D efforts in Japan, if successful, could further exacerbate a miserable United States trade situation, and California as a leading high-tech supplier state could be particularly adversely affected.

Leading highway experts acknowledge that a dramatic change must be made to handle the increasing demand for urban mobility. Extensive use of mass transit is expensive and is not well suited to serve the dispersed California travel patterns. A way to get more flow through the existing urban highways could lead to more cost effective solutions to today's and, more importantly, to tomorrow's traffic problems. Thus, the concept of the Automated Highway System (AHS) is being studied again as a means of providing considerably more capacity and improving safety.

The AHS idea is not a new one. In fact, General Motors developed and tested an automated vehicle prototype in 1958, but it was ahead of its time. The public sector showed little interest in the concept and the project was dropped. Since then, there have been spurts of interest and support for the AHS development in this country sponsored mainly by federal research projects:

- Department of Housing and Urban Development, New Systems Studies
- DOT sponsored Dual Mode studies
- UMTA Personal Rapid Transit and Automated Guideway Transit R&D

- FHWA sponsored AHS system studies at Ohio State University and General Motors Corporation

- Santa Barbara Electric Bus Project

The two early (late 1970's) FHWA studies (above) concluded that AHS is feasible and that a full scale AHS installation was practical in the 1990 - 2000 time frame. The General Motors effort indicated that "a technology development program is needed to bring AHS technology to the point which allows a first system deployment".

PATH Approach

The basic principle contained in the PATH program approach is that the AHS should be evolutionary and voluntary from the user's standpoint. It is a PATH goal to keep required vehicle on-board equipment cost approximately comparable to a good sound entertainment system. Even then, the purchaser of new automobiles must be able to readily perceive the added value of any AHS device.

The backbone of PATH will be utilization of existing technology, since the program is designed to provide near-term solutions to California's most pressing traffic problems and time is of the essence. The early phases will stress evaluation, test and demonstration of these proven techniques, and there are many to test.

To sort through these devices and innovative methodologies a series of special purpose seminars of leading, knowledgeable highway and related technology experts was held to prepare agendas for possible applications. For example, the Institute and Caltrans held the first such conference on October 28,29 and 30th, 1986 and 150 attended. The idea of an advanced technology program at Caltrans was broadly endorsed to "get going" with an R&D effort aimed at solving California's worsening traffic problems.

As the PATH approach has been structured to keep implementation options open and encourage a voluntary system, specific technology needs are not known. Rather, the program plan identifies three key functional technology areas: non-contact electrification, navigation, and automation and lays out near-term activities. PATH is also stressing near-term incremental improvements in urban highway system performance and early attention will be given to provide motorists with "real time traffic and routing" information. Once more informed driving judgments are made in critical segments of the system, then selected

automation may be tried on the densely traveled highway links. However, as more traffic is carried on the existing network, much more attention will have to be given to cleaner propulsion.

At the University's Richmond Field Station, which is near the UC Berkeley campus, Oakland, and San Francisco, there is ample indoor and outdoor space available for construction of test facilities, offices, and research laboratory space for interested industry tenants to co-locate with ITS PATH personnel.

The PATH philosophy is to build a cooperative venture of automakers, electronic control/sensor and computer equipment manufacturers, several state highway departments, the federal government, several cities/regional transit authorities and the universities. It is to combine these resources to address the most pressing traffic issues facing California's urban highways today and aim at providing the technology base for the next generation of smarter highways. As part of the coalition building, Caltrans and UC PATH personnel have played a key role in getting other states to join in this cooperative work.

Near-Term PATH R&D

The near-term PATH R&D activities are of two general types. University research is underway to better understand the feasibility or possible application of advanced technologies to the Los Angeles and San Francisco regions' traffic congestion problems. In parallel, there are field tests or small demonstrations of existing technologies to better understand their capabilities and to provide more data for the analysis going on in the university. Cross fertilization between these two distinct early PATH phases is stressed. Examples of the work to be supported for the next 2-3 years follow:

Lateral Control

There are obvious examples that one can envision where an effective lateral control mechanism could improve the traffic flow through restricted system bottlenecks. The Bay Area bridges are probably the most obvious case. In addition, there are several public bus systems operational in Europe and in Australia that have employed automatic lateral guidance to decrease required guideway space. Thus, the question is not so much one of technological feasibility, but one of how to introduce an effective, low cost lateral control system that can be implemented on an evolutionary basis.

One of the first assignments of the new PATH team was to tour Japan and Europe to assess the state of the art in the applicable technologies. On this trip, the PATH staff were able to ride existing lateral control systems. It is our opinion that current systems would be excessively rough in lateral jerk at freeway speeds and would not be enthusiastically accepted by private car owners. This is caused by a close tolerance control system that provides an immediate steering correction once deviations are sensed relative to the electronic reference.

Upon their return, this team initiated research aimed at providing preview (road geometry) information to the vehicle. This improved lateral control system incorporating artificial intelligence so that the controller doesn't need an "as soon as possible mentality", could, in theory at least, provide smoother transitions and improved ride quality. PATH is developing a passive, discrete "smart" marker system wherein the vehicle would sense the marker's presence and obtain lateral orientation plus encoded information relative to upcoming road geometry and other information.

Recent development of many passive devices (infrared, acoustic wave, etc) that utilize a portion of an incoming energy beam to reflect back an encoded message provides attractive marker options. The selection criterion for the initial marker was based primarily on the least expensive approach. Thus, the team at the Institute has developed, and is now in the early component testing phase of sensing permanent magnet markers. The field of the magnet itself provides lateral reference. Close spacing of these magnetic markers will provide a quasi-continuous reference line without the need for any "in-road" energy. By strategic positioning of the magnetic poles, binary information is encoded in a serial fashion to provide messages on upcoming road conditions that can be picked up and interpreted by the vehicle's on-board processor.

During the next 18 months, plans call for 1) selection and/or design of the applicable on-board magnetic sensors 2) investigation of how to effectively use the sensed information 3) design of a controller that makes use of artificial intelligence without too much on-board data processing to provide smooth lateral control.

In parallel, the UC Berkeley Sensor/Actuator Center has been asked to

investigate/design more robust discrete markers and sensors as possible alternatives. These would be used if future tests indicate that the magnetic marker approach either doesn't have adequate field strength for consistently reliable pickup or that more preview road information is needed from the marker reference system.

After initial low speed testing has been concluded, a decision will be made regarding suitability of one of the aforementioned discrete markers for further testing and evaluation at higher speeds.

Longitudinal Control

As was the case with lateral guidance, the first longitudinal control research task is a technical assessment by U.C. Davis researchers of previous findings in this field and a definition of a performance specification applicable to the goals and objectives of the PATH program. Concurrent with this technology assessment, other parallel efforts are being supported.

One is the design of a field experiment based upon a unique collision avoidance system developed by Radar Control Systems, Inc (RCS) of San Diego, California. RCS has developed, road tested, and field demonstrated a very interesting concept of using a doppler radar anti-collision warning device to assist drivers to avoid accidents or incidents. They have also tied the radar signals to a vehicle's cruise control and braking systems.

ITS, RCS and Caltrans will conduct simulations to define the response of the combined radar "car following" system and the expected dynamic response of a series of three automobiles provided by the Ford Motor Company. Independently, UC faculty and graduate students will be doing similar simulations on fleets of vehicles to determine what type of vehicle-to-vehicle communication system is required to improve the stability and safety of these platoons.

A large scale cooperative effort between RCS, Ford Motor Company, Caltrans, the California Highway Patrol, National Highway Transportation Safety Administration, the Federal Highway Administration, and the PATH team at the University of California is planned to obtain data regarding the car following concept. These tests will be conducted near San Diego on the new Interstate I-15 High Occupancy Vehicle lanes with three passenger cars and the RCS data gathering van to collect field data relative to stability of the string and

tendencies for small disturbances in the lead vehicle to propagate back through the platoon.

After data has been verified, a demonstration specification for a larger car-following experiment will be issued. It is envisioned that a follow-on competitive contract will be awarded to demonstrate the feasibility of platoons of perhaps 15 to 25 vehicles. A vehicle-to-vehicle communication system will be an integral part of this demonstration.

Non-Contact Electrification

Another aspect of **PATH** is the study of non-petroleum power, building on the Santa Barbara Electric Bus technology base developed by Systems Control Technology, Inc. of Palo Alto, California . A dynamic, electrified test facility is being constructed at the University's Richmond Field Station to test and evaluate the hardware.

A second generation, on-board power control system will be installed on the prototype bus and the test track will feature two-200 feet powered sections. Loop detectors will provide for automatic control of the supply of power to each segment of track for a duty cycle representing the Santa Barbara bus application. The performance of all the components and subsystems needed to effect the power transfer to charge batteries on the moving electric vehicle will be tested.

The Southern California Association of Governments will assist the University by conducting a highway electrification and automation impact study on the six-county Los Angeles region. Costs and benefits will be addressed and environmental, safety, mobility and energy issues will be evaluated. This work will also result in the development of one or more possible demonstration project proposals.

Another impact study is planned to determine the feasibility of roadway electrification and selected automation for electric buses in a busway/HOV application.

Navigation

Direction in the navigation area hinges, to a large degree, on the jurisdictional role of the different governmental agencies in the traffic control

operation. This issue is significant, particularly in large regional areas where strategic and tactical traffic information/control data must be issued from the central controlling source to be effective. Unlike aviation, responsibility and authority for central operating control are not defined in the highway network.

There is a worldwide emergence of on-board navigation equipment that perhaps will be offered to auto buyers in the next few years. In fact, one California company, Etak already has one such device available for commercial sale. To be most effective these navigation devices will probably be tied into an area wide traffic control system.

Previous studies suggest network travel time savings of perhaps 15% can be obtained by providing better real-time information to vehicle drivers. Continued interest prevails, especially if larger gains may be realized by better management of the system, and at present three demonstrations are planned for the 1989-90 time frame in West Berlin, London, and Los Angeles.

The Los Angeles "PATHfinder" experiment is smaller in scale than the others and is tailored to the California urban freeway situation. A 12 mile section of the Santa Monica freeway west of Los Angeles known as the "smart corridor" will be extensively instrumented as will parallel arterials in this "test section".

Plans call for some 25 General Motors vehicles equipped with Etak navigators to be driven by approximately 400 individual test drivers during the one year test. The purpose of the large number of drivers is to remove the familiarity aspect of driver/navigator and also to provide a statistically valid database for assessment purposes. This experiment is designed to answer questions such as: 1) the value of a dumb (no real time data) navigator, 2) the value added by "smart" navigators which know the whereabouts of incidents and anticipated delays in the network, and 3) the value of using navigator equipped vehicles as traffic flow sensors for central traffic monitoring/control.

The first several PATH papers were an assessment of the previous work and state of the art of navigator equipment. These studies suggested research topics. In addition, an initial simulation of the Pathfinder test section has been conducted and data obtained has been forwarded to those concerned with the framing of the eventual Pathfinder experiments. These studies have identified

areas requiring future improvement. The near-term PATH R&D in this effort will address the following:

1) Large Scale Network Flow Management - Simulations of traffic control concepts for a large scale regional area, including use of artificial intelligence, will lead to development of strategic and tactical methodologies to provide guidance to platoons of vehicles in key corridors. In parallel, other analyses will address the effect on user/system management benefits due to the nature, scale, and geometry/environment of the traffic network.

2) Designing improvements to provide real-time traffic information to drivers and means to handle freeway diversions (arterial control strategies) to gain better overall utilization of the network.

3) Working with drivers of the "Pathfinder" demonstration, experiments and/or simulations will be conducted to determine the optimal type and method of presentation of route guidance/control information.

California urban congestion is very bad and will worsen. It is and will continue to have adverse impacts on the economy, environment and health and safety of urban residents and commuters. The encouraging news is that the state recognizes that a bold, major breakthrough must be found to reverse this traffic stranglehold on society and has funded a Caltrans and University of California research activity.

The Program on Advanced Technology for the Highway has identified several promising technologies that may evolve through voluntary implementation. The success of this program will depend greatly upon industry participation in the early R&D tasks. However, this issue is much greater than that affecting one state - it is a national issue. We need strong federal leadership and research support, especially for the longer range R&D that industry and local governments can not support. I urge this committee to act upon this important matter and insist on stronger DOT leadership and financial support in this area. I thank you for your attention.

Mr. VALENTINE. Thank you, sir.

Mr. Haug, let me ask you if you would please give us some more detail on the relationship between—with the National Science Foundation and the operation at the University of Iowa.

Mr. HAUG. We have a National Science Foundation industry/university cooperative research center that's jointly supported by the Army Tank Automotive Command and the NASA Goddard Space Flight Center. We have 26 industrial participants who fund the block program. We do about $2 million a year and there are about 80 people involved in the center.

The main goal of the center is advanced computer-aided engineering techniques and one of the main developments that has bubbled out, partly due to our work with NASA and the Army, has been this high-speed computing capability that now supports real-time, man-in-the-loop simulation of robots and vehicles, but specifically in this case, vehicles.

Does that answer your question, sir?

Mr. VALENTINE. Yes.

One of the main criticisms of earlier simulator programs was underutilization. How much of a demand is there for these systems now and is that a problem or was it a problem? Was it a valid criticism?

Mr. HAUG. I think in the past, it may have been. The Daimler-Benz simulator, which is the world-class system today, is apparently—it apparently has a backlog. They're doing work for the French, doing work for the Italians. They've done work for other automobile companies. It's not clear how long they'll continue to do that. That facility has been quite busy, we understand.

The facility we're talking about will handle—will have capabilities that that one does not have. That one cannot handle—it cannot represent true ride quality, the harshness of road feeling, and that's a capability the automobile companies have indicated they must have in a simulator if they're going to get at the question of design for comfort and minimize fatigue.

So the fact that it would have additional capabilities leads us to believe that it would be substantially used. And that's the feedback that we've had from the auto industry, the truck industry, the State of California, their post—police officer training and standards—very nearly built one of these things just for their purposes. Now, they're coming onboard our study with some indication that they might like to use it.

So the indication thus far is that it would be a very heavily used facility.

Mr. VALENTINE. Going back to the simulator at—owned by the Mercedes-Benz Company, was that a cooperative effort between that corporation and some—and other automobile manufacturers or is that a wholly owned—

Mr. HAUG. No, sir—

Mr. VALENTINE. —Mercedes?

Mr. HAUG. —they—they—Mercedes-Benz did it. Now, they bought the graphics from—they had other contractors that did parts of it, but my understanding is that they got a very substantial tax incentive from the German Government to do that facility, something to the effect of a 50/50 cost-sharing.

But they bit the bullet and did it.

Mr. VALENTINE. Is there—some mention was made, I believe, of Volkswagen, was it not, in the use of the simulator—what other automobile manufacturers in the world, as far as you know, have simulators—simulators which would rival this German Mercedes—

Mr. HAUG. None rival. The best—the nearest comparable is apparently a Swedish simulator that has substantially less motion capability, but is very cleverly designed. My understanding, and I have not seen these things personally, is that the Volkswagen device is not so sophisticated.

Lyle Saxton talked this morning about the one that Federal Highway Administration runs here in the city. It does not have motion base. There are a number of those, but they limit you, then, to applications in which its principally visuals and not tactile or receptive feedback that's important in evaluating the driver's interaction with his vehicle.

Mr. VALENTINE. And, of course, Mercedes is—is a private corporation. I mean, the stock is traded publicly and you mentioned the fact that the German Government has substantial investment in that. Can you characterize it as a 50/50 proposition or—

Mr. HAUG. My understanding is that Mercedes got a very substantial tax incentive from the—

Mr. VALENTINE. That's right, that's what you said.

Mr. HAUG. —government to place it in Berlin, so that I don't believe it was a direct cost-sharing, but had the same effect.

By the way, Mike Finkelstein mentioned this morning, the French are very seriously considering a large-scale simulator and we have traded reports and their report indicates similar characteristics of the one that I outlined here. They have reviewed our report and indicate they agree with the level of sophistication that we intend—propose to put in such an advanced simulator.

Mr. VALENTINE. Is there a satisfactory system or method of exchanging ideas among world-class scientists such as yourself or do the Germans, for example, bring down a shroud of secrecy around what they have found out?

Mr. HAUG. Sir, thus far, people have been fairly open. It's been a gentleman's agreement. There's no—no formal agreement to exchange, but we have—have exchange with the French. We've provided our materials from the—to the Germans and they've provided more back, so the community's been relatively open thus far in terms of exchange of information.

Mr. VALENTINE. Thank you, sir.

Dr. Campbell, in your opinion, what programs are—are needed to ensure a proper and adequate transfer of technology from the university laboratories around the country to the private sector?

Mr. CAMPBELL. Well, I think what's going on now is doing the job reasonably well within the resources that are available because most of the things that we see coming into place today in terms of the crashworthiness work of the last 25 years were research-based and universities and research laboratories had their part in that, and of course, the industry did a great deal of their own research.

I'm reasonably satisfied with the mechanism by which such things that can be found out can be placed into use if they have—if they have the kind of merit. The biggest limiting feature, I'm sure,

like every other witness that ever comes up here, has been the level of resources. At the national level, there's had to be some really hard choices made in terms of the kind of—the richness of the research program or the diversity of the research program simply because of the fairly severe constraints in research available.

Within that—within that limit, I think we have seen a pretty good translation into on-the-road transfer of technology over the last 25 years in this area of crashworthiness.

Mr. VALENTINE. We'll have a hearing, as I have stated earlier today, next month on the question of the effect that the change in speed limit on some of these problems and without getting into any of the details and without asking you to tell me what the result is, I just wanted to ask you if the Safety Research Center at the University of North Carolina has any statistical information, if you are involved in attempting to make a judgment as to this speed limit situation.

Mr. CAMPBELL. Yes, sir, we have looked at it and a member of my staff, Dr. Patricia Waller, who's now head of the University of Michigan Center, was on the committee that looked at that.

The committee—if I recall, the general view at the time was that there might be 3- or 400 lives per year lost if the change was made and I think the numbers are reasonably consistent with that. It's a fairly straightforward political judgment, like it is anytime when you set a speed limit. You trade a certain number of lives for a certain amount of mobility and the political choice was made to raise the speed limit to 65.

I think it's sort of whimsical to suppose that there's no loss of life in that. It would be an interesting law of nature if we found that the—increasing energy with increasing speed sort of exempted the situation when you go from 55 to 65. In my mind, of course we are going to pay with some additional lives lost. I think it's about 300 a year.

I wouldn't—I didn't—that wasn't the choice I would have liked to seen made, but it's a kind of political choice that's always made when you set speed limits.

Mr. VALENTINE. Yes. And this thought just occurred to me, I suppose, that may sound a bit silly, but you know, you put a bullet in your hand and then you can use it in another way, I mean, to—one to say that speed doesn't kill.

But anyway—

Mr. CAMPBELL. May I just make a point?

The gentleman—I wish he was here—somebody could show him the arithmetic. He made the comment about—about the Indianapolis Speedway. I might just mention that the death rate per mile driven on the Indianapolis Speedway is around 3000 times as high as it is on the highways of the United States. Three thousand times as high.

Mr. VALENTINE. We can give you his name and address.

[Laughter.]

Mr. VALENTINE. Dr. Parsons, besides the PATH program, what other programs are currently under development in the Los Angeles area?

Mr. PARSONS. PATH is fairly sizable in itself, sir. It's about $8 million currently, and then in addition to the PATH program, there's the Pathfinder, which we did the original simulation for, but that's not included in PATH, per se. That's another—and you'll hear more about that from General Motors, so I won't dwell on that.

Then Caltrans itself and its laboratories is spending about another million on robotics and artificial intelligence on the maintenance aspects of these highways. Once we get the productivity up and there's more time use to move people on the highways, there's less time to maintain these highways, so you have to have a companion program on the advanced technology to maintain and keep these systems alive once we get more flow through them.

So there's a fairly—across the board, because, as I said, it's effecting the economy of our State.

Mr. VALENTINE. Thank you, sir.

Mr. Nagle.

Mr. NAGLE. You—I think you, frankly, probably left out the best part of your testimony, referring to page 2, Dr. Porter, you have some rather strong feelings about the government's policy towards R&D in the transportation area—

Mr. PARSONS. Lack of. I left the government over those reasons, yes, sir.

Mr. NAGLE. I'm sorry, I didn't hear that.

Mr. PARSONS. I left the Federal Government after 20 years because there were not policies in R&D.

Mr. NAGLE. How do you evaluate it today?

Mr. PARSONS. Worse.

Mr. VALENTINE. How long have you been gone?

Mr. PARSONS. I've been gone eight years and it's gone downhill in those eight years.

Mr. NAGLE. Do you think there's a need for a national transportation policy?

Mr. PARSONS. Sir?

Mr. NAGLE. Do you think there's a need to develop a national transportation policy?

Mr. PARSONS. I always have.

Mr. NAGLE. I guess you are so straightforward, it's hard to ask sophisticated questions.

[Laughter.]

Mr. NAGLE. Let me ask you some simple questions. What—if you were running the DOT, what would you do in terms of the Research Department specifically?

Mr. PARSONS. I'd first develop a national transportation policy and I'd do the R&D to make that happen.

Mr. NAGLE. Why don't we just rely on the private sector?

Mr. PARSONS. Private sector—

Mr. NAGLE. We are talking about the simulator here.

Mr. PARSONS. The private can't—sector can't do it when they're interwoven and all transportation, if you've got vehicles owned in the private sector and you've got the guideways owned in the public sector and it affects our tort liabilities on the liability, you have to have a cooperative effort. You just can't regulate one another. That's what's happened to this country. All the R&D we're

doing in transportation is defensive. The industry's spending their money to defend against our regulation.

You've got to get out of that mode and do cooperative things. That's why the hell I had to get out. I was coming unglued.

Mr. NAGLE. Dr. Campbell, do you agree?

Mr. CAMPBELL. Well, I think we have suffered from the adversarial relationships between DOT and the industry that is somewhat different from other countries. I won't argue that there's also political necessity for some of that, but I think it certainly has had its downside.

Mr. NAGLE. Dr. Haug, I was curious. Has the—the proposal, as I understand it, in terms of building a simulator, would call for a roughly 60/40 government/private sector/State sector match. The total project, I believe, if memory serves me correct, is about 25 million.

I'm kind of interested in what the private sector is saying to you, the auto manufacturers and others? Do they have an interest in this? Are they willing to come up with the money or they want to put the commitment where their—where their—

Mr. HAUG. We—we haven't been able to get them to put the money where their mouth is. We've gotten a lot of verbal pats on the back of support. I think—I'm afraid, a bit of a let's-wait-and-see-what-happens attitude. But it's very clear that they're seriously interested in using the facility.

In fact, the greatest concern that has been voiced is that they would not be able to get on it when they need it. In other words, it would be overutilized.

I—I am convinced, based on my interaction with the American Trucking Association, the trucking companies, the auto companies, that if the Federal Government makes a commitment to support this thing and get some State support, that we will get very substantial buy-in from the private sector.

Mr. NAGLE. Dr. Parsons—

Mr. PARSONS. It's not doctor; it's mister.

Mr. NAGLE. Pardon?

Mr. PARSONS. It's mister.

Mr. NAGLE. No, I promoted everybody this morning.

Mr. PARSONS. Okay.

Mr. NAGLE. Or demoted, as the case may be. I won't call you Congressmen.

But the simulator, in terms of—is that an area that we should be getting into, the government should be—should be involved in?

Mr. PARSONS. I don't know if the government should. There's a need for a simulator. We—we have a need right—in two of my projects right now—at the lower level of two of our projects, we have a need for a simulator. We've been working with Hughes Corporation in Los Angeles, who has a simulator. It doesn't have the moving platform base, but it does have good visuals. But it's difficult to get the private sector to put their money in. Until they see some movement either from this level of Congress or from the administration, they're just going to sit here and this thing's going to keep deteriorating.

Someone's got to take the lead and I think once that happens, they'll come forth and we'll start solving these problems.

Mr. NAGLE. What's the disadvantages of just waiting? Why don't we just wait and, you know, a couple of years, push this off? There are other problems we can work on.

Mr. HAUG. One, it's not going to happen. It seems very clear the Federal—the private sector is not going to spend the money to do a high-end one. I mean, we build national facilities all the time. How many billions do we put into accelerators? A mere 47,000 lives a year, it would seem to me that a small investment in a national research facility would have an impact.

Now, one of the other downsides to delaying this thing, if you do, the technology is ready now and technology's kind of tangible. There's some industrial firms that have invested in getting to the point where we could build one of these, and if there's no interest and no commitment, those people are going to go off and do other things. So, we're going to lose time, certainly.

I'd like to make one other comment, if I may. This business of investment in safety. I guess I'm puzzled. I understand the NHTSA—entire NHTSA R&D budget is $35 million a year. I left the Army Armament Command as a civilian in 1976. I was signing off on $50 million a year in guns and bullets R&D. Today, that's a quarter billion dollars, R&D in guns and bullets alone.

And we're putting, by national comparison, almost nothing into real research for highway safety.

Mr. NAGLE. Comments? Should we just wait, Mr. Campbell? Should we wait, Mr. Parsons?

Mr. CAMPBELL. Well, just to underline that, if you look at the—the number of years of life that people lose from various things like motor vehicle crashes or cardiovascular disease or cancer, for every year of lost life, the—compared to cardiovascular, there's about 11 times as much R&D funding. With respect to cancer, it's about 25 times as much funding. With respect to to AIDS, I don't know. I haven't even been able to make that calculation, so yes, the—in terms of the loss—loss of years of life, the resources in this area are orders of magnitude smaller than from the other disease—large loss-of-life categories.

Mr. PARSONS. That's the only part of your question I'd like to address. I think the academia may be the place to provide these facilities, if they are going to be used for both regulatory and product type work. They are at least neutral to the two adversary positions and we in California are providing facilities at both our Davis and Berkeley campus for some of this automation work and I think the university does play a good role between the two adversary sources there, so we'll get more use of it on that type of property.

I just hate to see that be the first thing we do and not walk out of here without any leadership or commitment that we're going to work on a bigger problem.

Mr. NAGLE. Thank you very much. Thank all of you very much.

Mr. VALENTINE. One final question, if I might.

Perhaps Dr. Haug would be the person. Would the system that the Germans developed, is that, in your opinion, worthy of emulation here? You talk about—is it practical not to maybe to select a General Motors or a Ford, but to hold out the—the expectation of a—of some tax help to a consortium of American builders? If that a feasible way to approach it?

Mr. HAUG. It may be. What we have been proposing as part of our study to DOT is something like that, a Federal investment with State and private investment buying into use of the facility, a shared cost. It's a form of inducement. I think you need something like that.

But just emulating the Daimler-Benz system, I think, would be a terrible mistake. Mike Finkelstein, I think, indicated we've learned a lot from that system and for the same dollar cost, we can make something that's five times better.

Mr. VALENTINE. Let me just issue an invitation to any of you here, any of the other panelists and others, if you would care to give to this subcommittee your thoughts as briefly as possible on that question, that might be something for us to give serious consideration to. It might be a way to get around some budgetary constraints here.

Do you have anything else, David?

Mr. NAGLE. No, sir.

Mr. VALENTINE. Thank you all, very, very much.

Our third and final panel consists of Mr. William Spreitzer—I hope I pronounced his name correctly—Manager, Intelligent Vehicle/Highway Coordination, General Motors Research Laboratories, Warren, Michigan; and Mr. Randolph Doi, Director, Intelligent Vehicle—Vehicles/Highway Systems/Automotive and Industrial Electronic Corporation, Motorola, Inc.

Welcome.

STATEMENTS OF WILLIAM SPREITZER, MANAGER, INTELLIGENT VEHICLE/HIGHWAY COORDINATION, GENERAL MOTORS RESEARCH LABORATORY, WARREN, MICHIGAN; AND RANDOLPH DOI, DIRECTOR, INTELLIGENT VEHICLES/HIGHWAY SYSTEMS/AUTOMOTIVE AND INDUSTRIAL ELECTRONIC GROUP (AIEG), MOTOROLA, INC..

Mr. SPREITZER. Thank you, Mr. Chairman.

We appreciate this invitation. Your hearing is a useful follow-up to the action taken by Congress last year in the fiscal year 1989 Department of Transportation appropriations bill, calling on DOT to undertake a comprehensive report to Congress on IVHS development.

The discussion paper recently issued by DOT as part of its preparation of this report to Congress, in our view, is a major contribution as it identifies many of the important issues which must be addressed in consideration of a U.S. IVHS program.

Now, there's little doubt, based on what was said this morning and all the efforts, that there's—steps must be taken to address traffic congestion. The conventional solutions just aren't enough.

But fortunately, linking IVHS with more traditional solutions may provide a broad policy to solve future traffic and highway needs. As we've heard, Europe and Japan have well-organized IVHS programs and are well ahead of work here in the U.S. You've heard of PROMETHEUS and its 650- to 800-million dollar, 400-topic, eight-year effort. The Japanese have 25 years of work in IVHS and for the automobile companies, let's use General Motors as an example, we have a major commitment to IVHS research

and development. Some of our current research programs and developments include efforts in night and bad-weather vision enhancement, adaptive cruise control, reconfigurable displays, diagnostics and advanced electrical systems, the highway driver's assistant, human factors research, autonomous mobility, sensors and accuators, traffic management using navigation, radar, automatic vehicle identification and location and fleet management.

As you've heard, in California, we've joined in partnership with the Federal Highway Administration and the California Department of Transportation, Caltrans, in the Pathfinder project. At the present time, the Pathfinder project is the only major industry/government initiative in this country, and although a limited number of U.S. universities and other industries are researching IVHS, the U.S. lacks major comprehensive national IVHS programs of the scale of the European and Japanese projects.

So there's clearly an urgency to establish a U.S. program. The risks of trailing the foreign programs include loss of technological competitiveness and the ability to market technology. Also, foreign development could set standards which the U.S. would have to use in addressing different needs here.

The DOT discussion paper I mentioned earlier represents a compelling argument for a broad-based national program. Equally, important, the paper presents information which also clearly shows the need for action now.

Through our participation in the Highway Users Federation, which is chaired by GM Executive Vice President, Alan Smith, General Motors has provided support for the organization and funding of a national program. The Federation's future highway program calls for the Department of Transportation to be the location of a national coordinated program. Also, the Federation supports a 10-year, $1 billion IVHS effort financed with highway trust fund revenues.

In summary, advanced technology promises significant contributions to improved transportation. There's a need for a national cooperative effort by government, industry and our intellectual community as represented by the universities. The needs of the driver, the highway user, are a key consideration in this national program, and there is an urgency. The time for action is now and GM is committed to serving major roles in that effort.

Thank you.

[The prepared statement of Mr. Spreitzer follows:]

Statement of

General Motors Corporation

before the

House Science, Space and Technology Subcommittee

on Transportation, Aviation and Materials

Presented by

William M. Spreitzer

GM Research Laboratories

June 7, 1989

Washington, D.C.

I am William M. Spreitzer, Manager, Vehicle-Highway Systems, General Motors Research Laboratories.

We appreciate the invitation to present our views on the application of advanced technologies — so-called Intelligent Vehicle-Highway Systems (IVHS) — to relief of traffic congestion. This is an important subject which covers many areas of current national interest, including U.S. competitiveness, fuel use, motor vehicle emissions, and transportation policy and highway funding.

Your hearing is a useful follow-up to the action taken by Congress last year in the fiscal year 1989 Department of Transportation appropriations bill, calling on the DOT to undertake a comprehensive report to Congress on IVHS development. The discussion paper recently released by DOT as part of its preparation of this report to Congress is a major contribution, as it identifies many of the important issues which must be addressed in consideration of a U.S. IVHS program.

There is little doubt that steps must be taken to address traffic congestion. Many of us are confronted with it every day. Even if we are fortunate to live in areas where the problem is not quite as acute as in metropolitan areas, it is still a concern because of the ramifications which extend to the air quality and efficient use of fuel.

The facts about traffic congestion are not comforting:

— more than 60 percent of all urban Interstate highway traffic in this country occurs under congested conditions, with traffic flowing at thirty-five miles-per-hour or less.

— By the Federal Highway Administration's calculation, traffic congestion causes Americans more than two billion hours of delay a year.

— A separate study commissioned by the Federal Highway Administration puts the cost of such delays at $73 billion a year in lost productivity.

— Traffic delays on the Interstate System are expected to increase in the range of 400 percent to 500 percent by the year 2000, depending on whose numbers you look at.

— In Los Angeles, the average freeway speed is expected to fall from 35 miles-per-hour today to just 11 miles-per-hour by the year 2010.

Conventional supply and demand solutions, such as more highways, improved mass transit, and driving restrictions will not work alone. On the supply side, the Interstate Highway System is nearly completed. In urban areas where congestion is worst, enough land may not be available for needed new roads.

Public transit also has not proven to be a solution to transportation problems. People want to maintain the privacy and independence of automobile over public transit travel. In addition, public transit will not resolve congestion problems resulting from new suburb-to-suburb commuting patterns, versus the old suburb-to-central city commuting patterns.

Further, on the demand side, any restrictions on the free use of automobiles are not likely to be welcomed by the driving population.

Linking IVHS with more traditional solutions thus may provide a broad policy solution to future traffic and highway needs.

Some vehicle and roadway systems using advanced technology are already in use. Systems using sensors and centralized controllers monitor and regulate ramp traffic entering freeways. Systems of synchronized lights improve traffic flow (and we certainly need wider use of these readily available systems). Examples of IVHS technology on vehicles include anti-lock braking systems and diagnostic systems.

Europe and Japan have well-organized IVHS programs and are well ahead of the projects in the U.S. In Europe, the PROMETHEUS project is a consortium of 16 domestic auto companies; over 70 computer, electronic, and communications companies and institutes; and six governments. U.S. and Japanese firms are excluded. The PROMETHEUS budget of $650 million will cover 400 topics of research over eight years. The primary objective of the program is accident

reduction, but improving highway transportation through enhanced communication and traffic control systems is a major secondary goal.

The Japanese have 25 years of work in IVHS. Two current programs, AMTICS and RA/CS, both consortia of industry and government, are developing driver information systems using on-board monitors to display the vehicle's position.

GM has a major commitment to IVHS research and development. Some of our current research programs and developments include efforts in night and bad weather vision enhancement; adaptive cruise control; reconfigurable displays; diagnostics and advanced electrical systems; the "Highway Driver's Assistant" program; human factors research; autonomous mobility, and sensors and actuators; traffic management using navigation, radar, automatic vehicle identification and location; and fleet management.

In California, we have joined in partnership with the Federal Highway Administration and the California Department of Transportation (Caltrans) in the PATHFINDER project. The object of the program is to research the effectiveness of on-board navigational and real-time traffic information as a partial solution for traffic congestion. A central traffic control center will relay information on road conditions and alternative routes to video monitors in 25 Oldsmobile Delta 88 automobiles. The three-year, $1.6 million project is planned for a heavily-used travel corridor in Los Angeles along the Santa Monica Freeway.

At present, the PATHFINDER project is the only major industry-government initiative in this country. Although a limited number of U.S. universities and other industries are researching the contribution of IVHS to resolving congestion and safety, the U.S. lacks major, comprehensive, national IVHS programs of the scale of the European and Japanese projects.

The breadth and complexity of the issues facing IVHS development in the U.S. and the rapidly advancing development of the foreign programs clearly point to the need for an integrated, broad-based national program. However, several issues need to be resolved in initiating such a program. The mix of public and private sector research facilities and financial contributions must be determined. Industry must be assured of some type of sharing of the risk associated with long-term IVHS research. And the issue of foreign participation must be resolved.

There is clearly an urgency to establish a U.S. program. The risks of trailing the foreign programs include loss of technological competitiveness and the ability to market technology. Also, foreign development could set IVHS standards which the U.S. would have to use in addressing different needs. The DOT discussion paper I mentioned earlier presents a compelling argument for a broad-based, national IVHS program. Equally important, the paper presents information which also clearly shows the need for action <u>now</u>.

Through our participation in the Highway Users Federation (which is chaired by GM Executive Vice President Alan Smith), General Motors has provided support for the organization and funding of a national IVHS program. The

Federation's future highway program calls for the Department of Transportation to be the location of a national coordinated program. Also, the Federation supports a 10 year, $1 billion IVHS effort, financed with Highway Trust Fund revenues. The Federation will provide written comments to the Subcommittee containing additional details on its recommendations.

In summary, advanced technology promises significant contributions to improved transportation. There is a need for a national cooperative effort by government, industry, and our intellectual community. The needs of the driver — the highway user — are a key consideration in that national program. There is an urgency. The time for action is now, and GM is committed to serving major roles in that effort.

Thank you.

Mr. VALENTINE. Thank you, sir.

Mr. Doi.

Mr. DOI. Thank you.

It's my pleasure to appear before you today. The area of advanced technology for use in the intelligent vehicle highway systems is of great interest to Motorola. Advances in communications, computers and control technology make the realization of IVHS systems a near-term possibility.

You've already heard about the extensive efforts in Europe and Japan that indicate the opinion is shared on a worldwide basis. Continuing advancements in foreign programs and technology present this country with a challenge to move forward rapidly to avoid the potential loss of yet another technology-based opportunity to foreign competition.

In the United States, IVHS is being described initially as having two major parts. The first element that you've heard described earlier is the advanced traffic management system, which consists of the sensor networks that will detect traffic conditions and traffic control centers that will monitor the information and communicate it to the driver.

The second element is the advanced driver information system, which you can witness outside in the Pathfinder car in the form of the navigation route guidance system.

Our feeling is that while these systems are somewhat functional on their own, their most effective implementation will be dependent upon a communications infrastructure, the link between traffic management systems outside the car with the driver information systems in the car. Providing this real-time information will greatly enhance our ability to address the problems of congestion and safety.

We feel it's also possible that these systems, when they're fully implemented, will provide information to help determine where new construction is warranted and how it should be done to provide the maximum results.

One of the elements that makes the future of IVHS so full of potential is that we already know much about the technology that is needed to make the system function. For example, the concept of data acquisition and control is now mature engineering science. We've also migrated beyond wired networks and have made similar significant advancements in the use of radio frequency technology for data communications.

Motorola has been involved with RF data communications for nearly two decades. In the early '70s, we began providing systems that replaced voice messages with data information. These early systems enhanced dispatcher operation and sent data at 600 and 1200 baud in a 25-kilohertz channel.

As 8-bit microprocessor capability advanced, we were able to increase the baud rate, 4800 baud in the same bandwidth. Today, entire systems, like taxi dispatch, package delivery operations and public safety and fire dispatch applications rely on RF infrastructures to communicate data.

More recently, as a result of digital signal processor technology, we've demonstrated the capability of providing 19,200 baud in the same bandwidth.

As future improvements in semiconductor technology continue, data communications capability will follow. We feel to establish a working definition of IVHS in the United States, we need to apply this technology to the problems of traffic congestion and safety and what I'd like to outline today is what we believe is needed for the dedicated ratio frequency communications infrastructure.

Three requirements must be addressed to make this critical link happen: research, standards and leadership. First, in order to design a communications infrastructure system, we need to conduct research on the data requirements. We must learn more about the volume of data that will be required to provide effective traffic systems management.

Second, following this research, there's a need to establish standards in three specific areas of the system. First, standards must be identified for digital map data bases and their structures as they relate to the traffic and roadway condition data. Second, operational standards must be established for data requirements of the system, both in terms of traffic control and predictive traffic flow. Third, possibly the most important issue for the communications standard is identification of spectrum on a nationwide basis.

Clearly, the research on the traffic management center must be completed before we can identify the bandwidth requirements.

The final area, but all-encompassing need to be addressed is that of leadership. The requirements I've outlined will have wide-ranging implications for all the participants who are working to make IVHS a reality in the United States. Auto makers, electronic suppliers, data base suppliers, the system operator—all of us must combine our efforts to find a rational system that will work for the U.S. To pull together these different parties and to facilitate making these decisions, we need national leadership to help drive the process.

The development of this system is a significant challenge, but we believe that it's worth the effort. At Motorola, we've committed our attention, time and resources to making IVHS a reality. For the past year, Motorola has been involved with several organizations in the U.S. pursuing these activities. We are a member of Mobility 2000, as well as a funding participant of the University of Michigan Transportation Research Institute.

We're also in the planning process for activities with Texas Transportation Institute and the Illinois University's Transportation Research Consortium.

Motorola intends to be the communications participant in as many meaningful future demonstrations as possible and available as a subject matter expert on request.

In addition, Motorola intends to continue its research activities, both at the University level and in conjunction with future research on advanced traffic management centers.

At the same time, the statement regarding our future support of IVHS is made with one caveat. For Motorola to continue its efforts, it is imperative that there be clear national leadership to pull together government, university, and industry participants. Further, we believe this leadership must emerge quickly. The nation must act now or U.S. interests face the potential of losing this opportunity to offshore competitors.

We believe the nation is ready for this challenge and we look forward to participating in this effort.

Thank you.

[The prepared statement of Mr. Doi follows:]

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C. 20515

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

Advanced Vehicle/Highway Technology and Human Factors Research

TESTIMONY OF RANDOLPH M. DOI

Director, Intelligent Vehicle/Highway Systems
Motorola, Inc.
Automotive and Industrial Electronics Group

TESTIMONY OF RANDOLPH M. DOI
before the
Subcommittee on Transportation, Aviation, and Materials
of the U.S. House of Representatives Committee
on Science, Space and Technology
June 7, 1989

Mr. Chairman and members of the Subcommittee:

It is my pleasure to appear before you today. I am Randolph M. Doi of Burr Ridge, Illinois, and I have been involved with Communications products and systems at Motorola for the past 17 years. I am Director of the strategic business unit which was formed to investigate and focus Motorola's capabilities on advanced vehicle/highway technologies.

This area of advanced technology for use in the Intelligent Vehicle/Highway Systems is of great interest to Motorola. Advances in communications, computers, and control process technology makes the realization and implementation of IVHS systems a near-term possibility.

Extensive activities in Europe and Japan indicate that this opinion is shared on a worldwide basis. In these countries, vehicle manufacturers and electronics companies, with the cooperation of their local governments, are investing heavily in the development of these types of systems. The European PROMETHEUS program alone is spending $700-$800 million over the next 5 years.

The development of foreign IVHS systems provides the U.S. with both an opportunity and a challenge. The opportunity is to examine research that may help us reduce traffic congestion and improve safety. At the same time, continuing advancements in foreign research, programs and technology also present this country with the challenge to move forward rapidly to avoid the potential loss of yet another technology-based opportunity to foreign competition.

In the United States, IVHS is being described initially as having two major parts. The first element, the Advanced Transportation Management System, consists of both sensor networks that will detect traffic densities and vehicle speeds, and traffic control centers that will monitor this information and communicate it to the driver. The second element of IVHS is known as The Advanced Driver Information System, a navigation/route guidance system on board the vehicle. While these systems are somewhat functional on their own, their most effective implementation will be dependent upon a communications infrastructure -- the "glue" that will link traffic management systems outside the car with the driver information/navigation systems inside the car.

Providing realtime information on current traffic and highway conditions to both drivers and traffic control centers will greatly enhance our ability to address the problems of congestion and safety by means other than construction. There is also a real possibility that these systems can provide information to help determine where new construction is warranted and how it should be done to provide the maximum results.

One of the elements that makes the future of IVHS so full of potential in the United States is that we already know much about the technology that is needed to make the system function.

For example, the concept of data acquisition and control is now a mature engineering science, and both speed and volume capabilities continue to grow at a rapid pace. Across the nation, manufacturing facilities and offices equipped with computer workstations depend on data acquisition and control to conduct their daily business.

We've also migrated beyond wired networks and have made similar, significant advancements in the use of radio frequency (RF) technology for data acquisition, control and communication.

Motorola has been involved with mobile RF-based data communications for nearly two decades. In the early 1970s, we began by providing systems that enhanced dispatcher operation by replacing voice messages with status or message information with the use of simple button operations. These early systems sent data at 600 and 1200 baud in a 25Khz channel. As 8-bit microprocessor capability advanced, we were able to increase the baud rate within the same bandwidth. Applications of this technology have also become more sophisticated as entire systems -- like taxi dispatch, package delivery operations, and public safety and fire dispatch applications -- rely on RF infrastructures to communicate data.

Today, as a result of digital signal processor technology, we've demonstrated the capability of providing 19.2K baud data over the same bandwidth. As future improvements in semiconductor technology continue, data communications capability will follow.

Based on the technology we have right now, we know IVHS is a near-term possibility. In fact, there are several examples of realtime systems being used on a daily basis that utilize technology very similar to that of IVHS. For example, many complex systems such as water and waste water operations, major electric utility power control and distribution centers use RF data communication. Similar technology is also being employed in this country in Air Traffic Control and in Advanced Train Control Systems.

Now, we need to apply this same technology to the problems of traffic congestion and safety by establishing a working definition of IVHS in the United States. What I'd like to outline today is what we believe is needed for the dedicated radio frequency communication infrastructure part of that system. Three requirements must be addressed to make this critical link happen: research, standards and leadership.

First, in order to design a communications infrastructure system that will yield the expected improvements, we need to conduct research on the data requirements that it must meet. We must learn more about the volume of data transfer that will be required to provide effective traffic systems management, safety improvements and optimal route guidance.

Second, following this research, there is a need to establish standards in three areas of the system:

1. Standards must be identified for digital map data bases and their structures and the related traffic or roadway condition data.

2. Operational standards must be established for data requirements of the traffic management system, both in terms of predictive traffic flow and control.

3. Possibly the most important issue for the communications standard is identification of spectrum available on a nationwide basis. Clearly, the previously mentioned research must be completed before we can determine the bandwidth required to manage the IVHS system.

The final but all encompassing need to be addressed is that of leadership. The decisions and standards I've outlined will have wide ranging implications for all of the participants that are working to make IVHS a reality in the United States. Automakers, electronic suppliers, electronic data base suppliers, the "system" operator -- all of us must combine our efforts, and we need leadership to work towards defining a rational system that will work for the U.S. To pull together these different parties, and to facilitate making these decisions, we need national leadership to help drive the process.

The development of a working IVHS system is a significant challenge, but we believe that it's worth the effort. At Motorola, we've committed our attention, time and resources to making IVHS a reality.

For the past year, Motorola has been involved with several organizations in the U.S. pursing these activities. We are an active member of both the steering committee and the working groups of Mobility 2000, a funding participant in the University of Michigan Transportation Research Institute's IVHS efforts, and in the planning process of activities with Texas Transportation Institute and the Illinois Universities Transportation Research Consortium. I am also fortunate to be a newly appointed member of the Transportation Research Board Executive Committee.

Motorola intends to be the communications participant in as many meaningful future demonstrations as possible and available as a subject matter expert on request. We also are contemplating joining both the European PROMETHEUS and Japanese AMTICS groups. Our initial focus is on the RF infrastructure required to provide data communications for the IVHS system. In the future, we'll focus on the communications needed to provide vehicle-to-vehicle interfaces for car caravans and other driver-assist developments.

In addition, Motorola intends to continue its support of research activities both at the university level and in conjunction with research being done on Advanced Traffic Management Centers. We will also support the communications requirements of any of the FHwA-sponsored demonstrations where requested.

As definitions of IVHS move closer to reality, we are positioned to be a turnkey supplier of communications infrastructure systems or a communications service supplier, depending on the chosen approach to provide these capabilities.

We believe that the United States has the ability to develop and implement an IVHS system equal to the best that's being developed in the world today. As a corporation, we are eager for this to happen, and on our part, we are taking the necessary steps and are committed to making the concept a reality.

At the same time, this statement regarding our future support of IVHS activities is made with one caveat.

For Motorola to continue its efforts, it is imperative that there be clear national leadership to pull together government, university and industry participants. Further, we believe this leadership must emerge quickly. The nation must act now or U.S. interests face the potential of losing this tremendous technological opportunity to offshore competitors.

We believe the nation is ready for this challenge and, with your leadership, we look forward to participating in this effort.

Mr. VALENTINE. Thank you, sir. We thank both of you.

Let me ask both of you, or each of you this question. Would you have any recommendations for us as to how best to ensure the cooperation of—of American automobile manufacturers and which of the manufacturers, domestic manufacturers, seem to be more interested, more receptive to the idea of a cooperative effort?

Mr. SPREITZER. Well, as others have said, we have a classic chicken-and-egg situation. The people responsibility for the roadway need assurance that there's equipment going to be available to use those facilities if they're built, and by the same token, the various manufacturers need some assurance that like facilities will be available in order for them to make the investments that are needed to take advantage of those facilities.

So we have an opportunity for a national cooperative effort where, if all parties get together, those concerns can be resolved and we think we have the basis for an agreement.

General Motors has active programs in a variety of areas, but we feel that now there's a need for this national cooperative effort. There's a question with regard to who should take the leadership, who should participate, but clearly there's a need for a definition, a better definition of the research and development activity and the program agenda. If we can move forward together, I think those objectives can be accomplished on a cooperative basis.

Mr. DOI. I would agree with Bill and I feel that the research requirement is there primarily because many portions of the system cannot be described until there is a cooperative definition that ties together the public side, traffic management center, and what requirements are there to the road network and then to the final—finally to the auto manufacturer portion of the system.

I think that last Saturday's demonstration in Traverse City shows that most of the auto manufacturers are very active, General Motors maybe more so than the other two at this point in time.

Mr. VALENTINE. Thank you.

Mr. Nagle.

Mr. NAGLE. What's it going to take to crack the egg, to get this thing going?

Mr. SPREITZER. One way would be to take things one step at a time. There's a need for data, information, which can be helpful, both to the people in government and to the people in industry to begin making these important decisions and commitments to the program. So the Pathfinder project is one example.

Here's a $1.6 million activity with funding provided by government at the Federal and State level with participation by General Motors on a cooperative basis to generate needed information, so I think we need additional demonstration and experimental activities of that kind at other geographic locations and for other like purposes throughout the country.

Others have mentioned the activities of Mobility 2000. This is an informal, self-appointed group, government, university and industry people who have gotten together to begin thinking about what the research development and demonstration needs are and what the agenda is.

Fortunately, their activities were in place when the Office of the Secretary of Transportation study was under way—

Mr. NAGLE. I don't mean this harshly, but darn it, you know, and I am tempted to use a different word, but you know, if we were going to gather data, we wouldn't be at the moon. We'd still be getting the data. We decided to go to the moon. I mean, it's a trite truism, but once in a while, you've got to reach out and you've got to say, you know, let's do it.

I want to know—I'm sitting here with the University of Iowa—I admit I have a vested interest in that project, but here we're sitting here. We've got the capability now developing and building the world-class simulator and we're looking at industry and saying, are you interested? Yeah, we're kind of interested in it. Will you put up any money for it? Well, we just don't know yet and we've got to look at this some more.

I mean, you know, $1.6 million in gathering data in California is—is a—this is the smallest possible step in the right direction. I mean, how do we get the thing launched? If you give us the opportunity, the Federal Government the opportunity to gather more data, we'll fill this room with it and we'll be no more closer to launching this ship than we were before we got that data.

Mr. SPREITZER. This program, unlike other public works programs, involves new actors, and as a result of that, there have been questions with regard to to the relative roles of the different organizations might play. But as the Highway Users Federation has pointed out, a commitment of $100 million a year over a 10-year period in research development and demonstration funding, which could be invested in universities and in other institutions, would be a big step in the right direction.

By the same token, there's a strong role here for not only the automobile industry, but the computer electronics and communications industries. In a large way, this is different for them than anything that's happened before and so they need some assurance with regard to the prospects for future business. If you will, there's a need for some risk-sharing on the part of the many participants.

Mr. NAGLE. Yeah. I don't disagree with that, but I—I get the feeling that we're just going to be treading water while we wait for somebody to take the leadership. Really, the responsibility to get this thing launched in a coordinated effort, recognizing the magnitude of the problem, recognizing the competitive opportunities for the American automobile industry, the American communications industry, the American computer industry really rests right here in the Federal Government, doesn't it?

Mr. SPREITZER. Well, one model is what's happened in Europe. Their industry took the initiative, but fortunately they had the umbrella of the public sector in the EUREKA program, which provided a favorable climate for those things to happen.

By contrast, in Japan, government has taken the initiative, but there's a much better relationship there in Japan between government and industry, and they have moved forward together. But in the conversations that we have with people in government, particularly at the Federal level, my friends say, it's really a case where industry needs to take more initiative, and our feeling is that there really is a need for government to take more initiative. To them in government, they feel perhaps a little despondent about that, but I've very optimistic. I think that's the basis for an agreement.

I think we're just on the threshold now of being able to move forward and all it takes is the key that will unlock this whole process. The expiration of the federally aided highway program is an opportunity, but that won't happen until 1991, and there's an urgency that suggests that we need to get programs started immediately.

Now the question becomes what actions do we need to take now, and we're open to suggestions and we would very much appreciate any conversations that we could have that would help foster that process.

Mr. NAGLE. I would be remiss, Mr. Chairman, and I see Mr. Porter is still here—I would be remiss if I didn't point out that if some of the Californians wanted to return to Iowa, where we do not have a traffic congestion problem, we could go a long ways toward alleviating your difficulties out there and I would suggest that part of the Pathfinder program that you build a road back to Iowa—

[Laughter.]

Mr. NAGLE. —put your excess people on that road and send them back. We'll get jobs for them; we'll educate them; we'll take care of them and, you know, we've got wide-open spaces. We can build more roads. I just didn't want this congestion problem to pass without throwing a word in for rural America, that we don't have that problem, but I'm still sympathetic.

Mr. VALENTINE. You might consider the Research Triangle Park area of Raleigh/Durham when you—

[Laughter.]

Mr. NAGLE. As long as there are places where you can go. I'm done, thank you.

Mr. VALENTINE. Thank you, sir.

Thank you, gentlemen, very much, and if any thoughts occur to you that you have not articulated, write us a letter. Thank all of you for being here.

Let me remind you now of the opportunity to view this vehicle at—now, as a matter of fact, at the Rayburn Horseshoe, and if you don't know where that is, anybody can tell you.

The subcommittee will stand adjourned.

[Whereupon, at 12:35 p.m., the subcommittee was adjourned, to reconvene subject to the call of the Chair.]

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